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RPP-17965, Rev. 0

SAFETY EVALUATION OF THE SINGLE-SHELL TANKS MODIFIED SLUICING WASTE RETRIEVAL SYSTEM

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Abstract: The purpose of this safety evaluation is to determine if the potential risk assiciated with using the single-shell tank modified sluicing system for retrieval of the 100-series SSTs in the tank farms is adequatley addressed and bounded by the current tank farms safety basis documented safety analysis and to determine if additional controls may be required.

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CH2MHILL
Hanford Group, Inc.

Richland, Washington

Contractor for the U.S. Department of Energy
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APPENDICES

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LIST OF TERMS

AC	administrative control
AIChE	American Institute of Chemical Engineers
ARF	airborne release fraction
CAM	continuous air monitor
DCRT	double-contained receiver tank
DSA	documented safety analysis
DST	double-shell tank
FHA	fire hazards analysis
GRE	gas release event
HAZOP	Hazards and Operability Study
HEPA	high-efficiency particulate air (filter)
HIHTL	hose-in-hose transfer line
LCO	limiting condition for operation
LFL	lower flammability limit
LPF	leak path factor
MAR	material at risk
NFPA	National Fire Protection Association
ORP	Office of River Protection
RF	respirable fraction
SER	Safety Evaluation Report
SSC	structures, systems, and components
SST	single-shell tank
TSR	technical safety requirements
ULD	unit-liter dose

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1.0 PURPOSE AND SCOPE

1.1 PURPOSE

The purpose of this safety evaluation is to determine if the potential risk associated with using the single-shell tank (SST) modified sluicing system for retrieval of the 100-series SSTs in the tank farms is adequately addressed and bounded by the current tank farms safety basis (documented safety analysis [DSA]) and to determine if additional controls may be required. This safety evaluation also supports the requirement to perform a generic safety basis amendment for the retrieval of any additional SSTs (other than 241-S-112, and 241-U-107) by modified sluicing from the U.S. Department of Energy, Office of River Protection (ORP) Safety Evaluation Report (SER) 03-TED-066, *Safety Evaluation Report (SER) for Approval of Justification for Continued Operation (JCO) for Tank Farms Single-Shell Tank (SST) Retrieval/Closure Modified Sluicing.*

1.2 SCOPE

The scope of this safety evaluation is SST modified sluicing waste retrieval system operations that are planned for conduct in 100-series SSTs. Waste from the 100-series tanks is planned to be transferred to double-shell tank (DST) storage. Initially modified sluicing campaigns are planned for the 241-S, 241-C, and 241-U tank farms. This safety evaluation is based on two separate designs originally prepared for SSTs 241-C-106 and 241-S-112; however, the design for these two tanks is expected to be bounding for future tanks to be modified sluiced. When the system designs and processes for the retrieval of these subsequent tank farms' 100-series tanks are established, the analysis of this safety evaluation will be reviewed via the Unreviewed Safety Question process to determine whether this analysis satisfactorily bounds the retrievals from these subsequent tank farms.

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2.0 DESCRIPTION OF THE SINGLE-SHELL TANK MODIFIED SLUICING WASTE RETRIEVAL SYSTEM DESIGN AND PROCESS

SST modified sluicing waste retrieval systems will retrieve waste from designated tanks to the extent needed for tank closure and transfer the retrieved waste to the DST system. The SST modified sluicing waste retrieval system is designed to dissolve SST crystallized salt and to mobilize sludge through the application of high pressure water or supernatant spray to break down the waste salt, sludge, and solids and to direct the waste to the intake of a slurry transfer pump for transfer into the DST system. Various SST waste retrieval system sluicing designs may be used. Each system uses sluicing nozzles, waste transfer pump(s), monitoring and control systems, portable exhauster ventilation, and new and existing waste transfer systems. Support systems necessary for the sluicing design include raw water and electrical supply.

The SST waste retrieval system sluicing designs employ remote controlled or automatic sluicing nozzles that are strategically placed and installed in the tank headspace via SST risers. The number of sluicing nozzles can vary depending on the amount and location of solidified waste within the SST. Current sluicing designs rely upon one to six sluicing nozzles. The nozzle system is designed to aim pressurized fluid (raw water or supernatant) that will break up, mobilize, and move the sludge and compacted solids slurry to a location where they are picked up by a slurry transfer pump. The design flow rate of the remote operated sluicing nozzles varies between 50 gal/min and 100 gal/min with operating pressures of between 60 lb/in^2 and 100 lb/in^2. The automatic self-indexing sluicers operate at a flow rate of approximately 20 gal/min. The nozzle spray range will cover a minimum range of 30 ft up to a maximum range of approximately 50 ft. The sluicers are capable of 360 degree rotation in the horizontal, and vertical pan and tilt from 0 degrees to 90 degrees.

The nozzles are remotely directed from a control trailer by use of hydraulic or electric controls, with the nozzle position displayed on 2 m, azimuth and elevation (pan and tilt). Automatic self-indexing sluicing nozzles may also be used that do not require operator action.

SST waste retrieval system sluicing designs use different pump configurations that could include one or two pumps in series for waste retrieval, with the possibility of the addition of a separate supernatant re-circulation pump. The primary waste retrieval pump(s) are typically located near the center of the SST. The pump(s) are physically located within the SST or external to the tank in an enclosed structure, with the pump suction draw located near the tank bottom. Pump designs includes centrifugal pumps and progressive cavity positive displacement pumps. Except for positive displacement pumps where higher pressures are possible, the slurry transfer pumps operate at flow rates and pressures bounded by existing waste transfer pumps (see Section 2.4.2.3). A supernatant re-circulation pump may be used during the sluicing operation to skim the liquid layer, providing re-circulation capability to the sluicing system. The supernatant re-circulation pump operates at a nominal 100 gal/min at 100 lb/in^2.

Dilution water may be used to aid in the retrieval process by diluting the slurry to the appropriate specific gravity conducive to waste transfer. Dilution water can also be supplied to the slurry transfer pump to flush the transfer line. Dilution water can be added at up to 100 gal/min, with a nominal flow rate of 50 gal/min.

Operators located within a control trailer direct the monitoring and control system. The control trailer could be located within the tank farm or nearby outside the fenced boundary. The control trailer contains sluicing operation controls and closed-circuit television monitors and controls. The sluice nozzles are remotely operated using joysticks and observed via the television monitors displaying the view from cameras located within the source SST. In-tank lighting is used to enhance in-tank camera viewing. During retrieval operations, the video cameras provide visual feedback on the waste mobilization process; assisting operations in the control of water or supernatant spray application and moving slurry to the transfer pump suction.

Process parameters that are monitored during the sluicing process include system temperatures, pressures, waste temperature and density, flow rates of the system, and raw water flow and waste transfer volume. Liquid depth in the SST pool is also monitored.

Active ventilation is connected to the SST to aid the sluicing operations by removing aerosols and/or fog generated during sluicing to enable better visual monitoring capability. The tank ventilation system is comprised of an inlet high-efficiency particulate air (HEPA) filter, a portable exhauster, and a demister. The portable exhauster contains a heater, pre-filter, two stages of HEPA filters, a fan, an exhaust stack, an effluent monitoring system, and ventilation stack continuous air monitor interlock system. The portable exhausters use variable speed blowers that operate at between 100 ft^3/min and 1,000 ft^3 /min.

The slurry transfer pumping system is connected to either an existing underground waste transfer system or to a hose-in-hose transfer line (HIHTL) that is used to transfer the retrieved waste to the DST system. The HIHTL is heat traced and insulated. The waste transfer system includes required leak detection and alarm capabilities.

The SST waste retrieval system sluicing designs use raw water and electric power. Raw water is provided to the sluicing nozzles and auxiliary equipment. Backflow preventers or service water pressure detection systems are used to assure that no contamination of the raw water supply can occur. Raw water supply may be heat traced and insulated as necessary. Heated water may also be provided.

Electric power is used to power the operation control trailers, the portable exhausters, electric pump motors, raw water and waste transfer line heat tracing, and the process monitoring and control systems, including leak detection and alarms. Electric power is provided via connection to the Hanford Site power distribution system or via portable power generators.

3.0 HAZARD ANALYSIS

3.1 HAZARD IDENTIFICATION

SST modified sluicing waste retrieval system operations are proposed activities that have not been approved under the DSA; however, approval of modified sluicing waste retrieval system operations is approved under the final safety analysis report for SSTs 241-S-112 and 241-U-107 via ORP SER 03-TED-066 and SST 241-C-106 via a negative Unreviewed Safety Question and ORP SER 03-TED-029, "Approval of Interim Authorization Using Alternate Controls Related to the Operation of Active Ventilation on Single-Shell Tank (SST) 241-C-106 During Accelerated Waste Retrieval," which allowed for the passive breather filter to be closed during active ventilation.

A Hazards and Operability Study (HAZOP) was performed to identify and evaluate potential hazards associated with the SST modified sluicing waste retrieval system for 100-series SSTs retrieval. In addition, HAZOPs performed on SSTs 241-S-112 (RPP-9014, *Process Hazards Analysis for the S-112 Saltcake Waste Retrieval Technology Demonstration Project Preconceptual Design*), 241-U-107 (RPP-7689, *Hazard Evaluation for Single-Shell Retrieval Via Salt Cake Dissolution Proof of Concept in Tank 241-U-107*), and 241-C-106 (RPP-13557, *Safety Evaluation of the Phase I Retrieval of Liquid Waste from Single-Shell Tank 241-C-106*) were reformatted to conform with the DSA and were added to the modified sluicing HAZOP.

The results of the combined HAZOPs were reviewed to identify potential hazardous conditions associated with the modified sluicing waste retrieval system that may not be adequately bounded or represented by the DSA analyzed representative accidents.

3.2 METHODOLOGY

The hazards identification and evaluation of modified sluicing waste retrieval system operations used the HAZOP method. A HAZOP is a systematic process for identifying potential causes and consequences of off-normal conditions in a system or process. The HAZOP uses a team leader to guide an interdisciplinary team of subject matter experts (Appendix A) in evaluating a system or process. The HAZOP process is based on "brainstorming" and uses a standardized set of process parameters (e.g., temperature, pressure, flow) and guide words (e.g., high, low, part of, reverse) to facilitate the "brainstorming." Table 3-1 presents a list of process parameters and guide words. The HAZOP team also established consequence and frequency estimates for radiological and toxicological effects to three receptor categories. These are offsite individual, onsite worker, and facility worker. Each hazardous condition was evaluated using a qualitative estimation process, without consideration of the application of any controls. The definitions/criteria for the information developed during the HAZOP process are found in Appendix B.

Table 3-1. Deviation Guide For Process Variables.

Guide Words / Process Parameter	NO, NOT,1 NONE	LESS, LOW, SHORT	MORE, HIGH, LONG	PART OF	AS WELL AS, ALSO	OTHER THAN, WHERE ELSE	REVERSE
FLOW	No Flow	Low Rate, Low Total	High Rate, High Total	Misdirection, Material in Inappropriate Areas	Contamination, Impurities	Wrong Material	Backflow
PRESSURE	Open to Atmosphere	Low Pressure	High Pressure	--	--	--	Vacuum
TEMPERATURE	Freezing	Low Temperature	High Temperature	--	--	--	Auto-refrigeration
LEVEL	Empty	Low Level	High Level	Low Interface	High Interface	--	--
CONFINEMENT	No Confinement	Degraded Confinement	--	--	--	Bypass Pathway	--
TIME PROCEDURE	Skipped or missing Step	Too Short, Too Little	Too Long, Too Much	Action(s) Skipped	Extra Action(s) (Shortcuts)	Wrong Action	Out of Order, Opposite
SPEED	Stopped	Too Slow	Too Fast	Out of Synch	--	Web or Belt Break	Backward
COMPOSITION/ CONCENTRATION	Missing Ingredient	Less Ingredient/ Low Concentration	More Ingredient/ High Concentration	Missing Ingredient	Contaminant/ Additional Ingredient	Wrong Ingredient	--
pH	--	Low pH	High pH	--	Additional Acid, Additional Base	Wrong Acid, Wrong Base	--
VISCOSITY	--	Low Viscosity	High Viscosity	--	--	--	--
VOLTAGE	No Voltage	Voltage Low	Voltage High	Wrong Waveform	Interference Voltage	Wrong Frequency, AC instead of DC DC instead of AC	Wrong Polarity
CURRENT	No Current	Current Low	Current High	--	--	Current Fluctuating	Wrong Polarity
STATIC	No Static Charge (when required)	--	Static Charge	--	--	--	--
AGITATION	No Mixing	Poor Mixing	Excessive Mixing	Mixing Interruption	Foaming	--	Phase Separation
REACTION	No Reaction	Slow Reaction	Runaway Reaction	Partial Reaction	Side Reaction	Wrong Reaction	Decomposition
STRUCTURAL INTEGRITY	Structural Failure	Less Integrity	More Integrity	--	--	--	--
SHIELDING	No Shielding	Less Shielding	More Shielding	--	--	Wrong Type of Shielding	--
SPECIAL	Utility Failure	External Leak	External Rupture	Tube Leak	Tube Rupture	Startup, Shutdown, Maintenance	--

The expertise and experience of the HAZOP team is of primary importance in establishing the credibility of the analysis because of the largely qualitative nature of the HAZOP process. The attendance roster is included in Appendix A to document the presence of each team member. The HAZOP process is recognized by the American Institute of Chemical Engineers (AIChE) and is described in *Guidelines for Hazard Evaluation Procedures* (AIChE 1992).

One of the important features of a HAZOP is the division of a process or activity into discrete segments called nodes. Node selection is designed to facilitate the hazard identification process by focusing the attention of the team on specific process sections or operating steps. The team applies the HAZOP process to each node in a stepwise fashion. The waste retrieval system HAZOP for the modified sluicing system was based on the following nodes to capture points in the process where deviations could result in significant consequences:

- Node A: Equipment installation and decommissioning
- Node B: Water supply system, including flush systems for transfer lines
- Node C: Sluicing system
- Node D: Transfer pump
- Node E: Transfer lines, SST to DST and SST recirculation
- Node F: SST ventilation system
- Node G: DST receiver tank ventilation system
- Node H: SST being retrieved
- Node I: DST receiver tank
- Node J: Instrumentation and camera system
- Node K: Criticality Concerns (what if?).

The hazardous conditions presented under Node K are intended to indicate that the hazard evaluation team performed a broad brush "what if" evaluation to ensure that criticality concerns are appropriately addressed.

The HAZOP results were used as input for this safety evaluation to identify and evaluate hazardous conditions that may not be adequately addressed by the tank farms safety basis.

The HAZOP data was used in this safety evaluation to compare the identified hazardous conditions to the DSA representative and/or candidate accidents. The safety evaluation includes consideration of the safety basis controls (i.e., safety SSCs and technical safety requirements [TSR]), which the HAZOP did not consider. Any HAZOP identified hazardous conditions that were estimated not to be adequately addressed by the DSA accident analysis and controls are discussed in this safety evaluation.

3.3 ASSUMPTIONS

No key assumptions were identified for this safety evaluation.

3.4 HAZOP RESULTS

The HAZOP team identified 111 hazardous conditions associated with operation of the SST waste retrieval modified sluicing system. The team used the consolidated hazardous conditions from the HAZOPs for SSTs 241-S-112 (RPP-9014), 241-U-107 (RPP-7689), and 241-C-106 (RPP-13557) and the Justification for Continued Operation for modified sluicing in SSTs 241-S-112 and 241-U-107 as a starting point, identifying new hazardous conditions as necessary.

3.5 HAZARDOUS CONDITION SCREENING

Hazardous conditions were screened to determine if they 1) are not represented by a DSA representative accident, 2) are similar to, but not bounded by a DSA representative accident, 3) are similar to and bounded by a DSA representative accident but are unique in regard to process or control applicability, or 4) are not appropriately represented by a candidate accident. Hazardous conditions meeting one or more of these criteria require further evaluation. Chapters 4.0 and 5.0 of this safety evaluation document the evaluation of these hazardous conditions. Hazardous conditions not meeting the screening criteria were not further evaluated and will not be incorporated into the DSA hazard evaluation database.

Hazardous conditions involving exposure to radioactive and other hazardous materials were assigned a representative accident and/or a candidate accident designator as appropriate. The representative accident designator allows cross reference to the appropriate analysis in the DSA. Candidate accident designators allow hazardous conditions to be compared with the hazardous conditions contained in the DSA hazard evaluation database. Thirty-one hazardous conditions were identified as meeting the screening criteria and are presented in Appendix C. The information in Appendix C reflects the final results of this safety evaluation.

The break down of these hazardous conditions is as follows:

- 10 Representative Accident 1, Flammable Gas Accidents (Candidate Accidents 04/05)
- 6 Representative Accident 2, Nuclear Criticality (Candidate Accident 01)
- 3 Representative Accident 4, Release from Contaminated Facility (Candidate Accident 07)
- 3 Representative Accident 13, Waste Transfer Leak (Candidate Accident 33)
- 8 *Identifiable to a Candidate Accident but DSA Hazardous Conditions Determined to be Risk Bin III or IV (i.e., no Representative Accident identified),* Filtration Failures Leading to Unfiltered Releases (Candidate Accidents 06/18B)
- 1 *Identifiable to a Candidate Accident but DSA Hazardous Conditions Determined to be Risk Bin III or IV (i.e., no Representative Accident identified)*, Tank Bump (Candidate Accident 18A)

3.6 DETAILED DISCUSSION

The following text provides a brief discussion of the specific reasons that hazardous conditions were identified for further evaluation:

Ten hazardous conditions involving flammable gas accidents (Representative Accident 1, Candidate Accident 05, deflagrations in other than DSTs) were identified as having the characteristics sufficiently different from the hazardous conditions in the DSA hazard evaluation database to warrant further evaluation. The specific concern involves deflagrations resulting from induced gas release events (GRE). The process of retrieving waste by sluicing from an SST has the potential for creating induced releases of flammable gas that were not evaluated in the DSA.

Hazardous conditions involving nuclear criticality (Representative Accident 2, Candidate Accident 01) were identified that are very similar to the hazardous conditions in the DSA hazard evaluation database. They are included with the hazardous conditions requiring further evaluation to ensure that criticality concerns are verified as adequately addressed.

Three hazardous conditions involving release from contaminated facility (Representative Accident 4, Candidate Accident 07) were identified as having characteristics sufficiently different from the hazardous conditions in the DSA hazard evaluation database to warrant further evaluation. The concern is associated with the possible use of a hydraulic motor driven positive displacement transfer pump, hydraulically powered nozzle indexer (rotation), and hydraulically powered articulation actuator (radial position). Use of hydraulic power creates the potential for combustible fluid to be released and ignited in a contaminated area pit which is not addressed in the current DSA.

Three hazardous conditions involving waste leaks (Representative Accident 13, Candidate Accidents 33A, 33C, and 33E) were identified as having characteristics sufficiently different from the hazardous conditions in the DSA hazard evaluation database to warrant further evaluation. The specific concerns involve the potential for transfer system pressures higher than what was evaluated in the current DSA analysis. This is due to the use of a progressive cavity positive displacement pump to transfer mobilized waste from an SST. Positive displacement pumps have the potential for producing very high pressures under the off-normal conditions.

Eight hazardous conditions associated with filtration failures leading to unfiltered releases (Candidate Accidents 06 and 18B) were identified as having higher consequences than reported in the DSA. The specific concern involves the potential for the release source term to be greater than what was used in the current DSA analysis.

One hazardous condition associated with tank bump (Candidate Accident 18A) was identified as having characteristics sufficiently different from the hazardous conditions in the DSA hazard evaluation database to warrant further evaluation. The specific concern involves water infiltration and subsequent steam evolution behind the steel SST liner. Such an event has happened in the tank farms in the past. The current DSA control suit does not address this accident. However, based on the following qualitative argument, no discussion is necessary in Chapters 4.0 or 5.0 of this safety evaluation.

Tank bump resulting from water intrusion behind an SST liner is judged to have a frequency "beyond extremely unlikely. Hazardous conditions with a frequency of "beyond extremely unlikely" require no further evaluation. The frequency estimate is based on the fact that a heat load of > 11.3°kW is required to result in waste temperatures that exceed the saturation temperature of water (RPP-6213). Only four SSTs (241-A-104, 241-AX-104, 241-C-103, and 241-C-107) have heat loads in excess of 11.3 kW (RPP-5926, *Steady-State Flammable Gas Release Rate and Lower Flammability Level Evaluation for Hanford Tank Waste*). Current waste temperature data shows that these tanks are well below the saturation temperature of water. The highest temperature found in these four tanks is 76 °C (168.8 °F) (SST 241-A-104). These tanks have been under passive cooling conditions for many years and show no trend of increasing temperature. Since the temperature is substantially below the saturation of water there is no possibility of steam bubble formation behind the tank liner no matter what quantity of water is involved.

4.0 ACCIDENT ANALYSIS

4.1 EVALUATION OF RISK FROM MODIFIED SLUICING OF WASTE FOR DSA REPRESENTATIVE ACCIDENTS

4.1.1 Flammable Gas Accidents

4.1.1.1 DSA Representative Accident

The DSA related representative accident is (Candidate Accident 04/05, Flammable Gas Accidents and is addressed in DSA Section 3.3.2.4.1, "Flammable Gas Accidents," addresses this hazardous condition. The DSA evaluates flammable gas hazards in all tank farm facilities where waste is present, including DSTs, SSTs, double-contained receiver tanks (DCRT), active catch tanks, inactive tanks, waste transfer-associated structures, waste transfer systems, and waste-intruding equipment. There are two mechanisms by which waste-generated flammable gases can reach high concentrations in tank farm facilities. First, flammable gases generated by the waste are continuously released into vapor spaces. In the absence of adequate ventilation, the steady-state concentration of these gases can potentially exceed the lower flammability limit (LFL). Second, a fraction of the gas generated by the waste can be retained within the waste. This retained gas can be released in a spontaneous or induced GRE thereby increasing the flammable gas concentration in a tank headspace to above the LFL.

The representative accident for DSTs (Candidate Accident 04) is a headspace deflagration due to a steady-state accumulation of flammable gas or a spontaneous GRE. Without controls, the DSA qualitatively determined the frequency of a headspace deflagration in a DST due to a steady-state accumulation of flammable gases or a spontaneous GRE to be "unlikely." The deflagration in the headspace of a DST is qualitatively determined to result in "low" onsite radiological consequences, "low" offsite toxicological consequences, and "moderate" onsite toxicological consequences. Safety-significant structures, systems, and components (SSC) and/or TSRs are required based on the Risk Bin II result associated with the onsite toxicological consequences.

Other hazardous conditions associated with the DST flammable gas representative accident address various DST deflagration scenarios (e.g., different flammable gas sources, different ignition sources). The other accident scenarios identified in the DSA as requiring safety-significant SSCs and/or TSRs based on either their risk binning results or their potential for significant facility worker consequences are DST Headspace Deflagration Due to an Induced GRE, Deflagration in a DST Annulus, Deflagration in DST Waste-Intruding Equipment, Deflagration in a Waste Transfer Line, and DST Gasoline Deflagration. The DST accident scenarios relevant to modified sluicing operations are summarized below:

- **DST Headspace Deflagration Due to an Induced GRE.** This hazardous condition is identical to the representative accident except that the flammable gas concentration in the headspace reaches the LFL due to an induced GRE. As documented in PNNL-13781, *Effects of Globally Waste-Disturbing Activities on Gas Generation, Retention, and Release in Hanford Waste Tanks*, activities with the potential to induce a significant GRE in DSTs are waste transfers, mixer pump operation, air lift circulator operation, and large water or chemical additions. Because these are current or planned activities, the frequency without controls was qualitatively determined to be "anticipated." Safety-significant SSCs and/or TSRs are required based on the Risk Bin I result associated with the onsite toxicological consequences.

- **Deflagration in DST Waste-Intruding Equipment.** Waste-intruding equipment is equipment that is inserted below the waste surface and is open ended, breached, or uses a mechanical seal as a barrier to electrical components and creates an unvented vapor space where flammable gases generated or retained in the waste may accumulate (e.g., core sample drill pipes, pump suction legs, weight factor dip tubes). Incidents have occurred where the concentration of flammable gas in waste-intruding equipment has exceeded the LFL. These incidents were attributed to the equipment encountering gas pockets in the waste. Flammable gas concentrations exceeding the LFL in waste-intruding equipment have also resulted from steady-state generation and accumulation. Given this operational history, the frequency of a deflagration in waste-intruding equipment without controls was qualitatively determined to be "anticipated." The consequences were qualitatively determined to be "low" for the onsite and offsite receptors due to the localized nature of the deflagration and the smaller material at risk (MAR) relative to the representative accident. This frequency/consequence combination yields a Risk Bin III result for the onsite and offsite receptors. It was, however, qualitatively determined that a deflagration in waste-intruding equipment could result in significant facility worker consequences (i.e., a prompt fatality or serious injuries or significant radiological or chemical exposures). Accordingly, safety-significant SSCs and/or TSRs are required. This evaluation is also applicable to waste-intruding equipment in SSTs.

- **Deflagration in a Waste Transfer Line.** There is limited potential for flammable gas accumulation and ignition in either the primary or encasement piping of a waste transfer line. The frequency of a deflagration without controls was qualitatively determined to be "unlikely." The consequences were qualitatively determined to be "low" for the onsite and offsite receptors due to the limited volume of hydrogen and the smaller MAR relative to the representative accident. This frequency/consequence combination yields a Risk Bin III result for the onsite and offsite receptors. It was, however, qualitatively determined that a deflagration in a waste transfer line could result in significant facility worker consequences (i.e., a prompt fatality or serious injuries or significant radiological or chemical exposures). Accordingly, safety-significant SSCs and/or TSRs are required.

The representative accident for SSTs (Candidate Accident 05) is a headspace deflagration due to a steady-state accumulation of flammable gas. Without controls, the DSA qualitatively determined the frequency of a headspace deflagration in an SST due to a steady-state accumulation of flammable gas to be "unlikely." The deflagration in the headspace of an SST is qualitatively determined to result in "moderate" onsite radiological consequences, "low" offsite toxicological consequences, and "moderate" onsite toxicological consequences. Safety-significant SSCs and/or TSRs are required based on the Risk Bin II result associated with the onsite radiological and toxicological consequences.

Other hazardous conditions associated with the SST flammable gas representative accident address various SST deflagration scenarios (e.g., different flammable gas sources, different ignition sources). The other accident scenarios identified in the DSA as requiring safety-significant SSCs and/or TSRs based on either their risk binning results or their potential for significant facility worker consequences are SST Headspace Deflagration Due to an Induced GRE, Deflagration in SST Waste-Intruding Equipment, SST Gasoline Deflagration, Deflagration in a Double-Contained Receiver Tank, Deflagration in an Active Catch Tank, Deflagration in a Waste Transfer-Associated Structure, Deflagration in a Waste Transport Cask, and Deflagration in Inactive Tanks. The accident scenarios relevant to modified sluicing operations are summarized below:

- **SST Headspace Deflagration Due to an Induced GRE.** This hazardous condition is identical to the representative accident except that the flammable gas concentration in the headspace reaches the LFL due to an induced GRE. As documented in PNNL-13781, activities with the potential to induce a significant GRE in SSTs are saltwell pumping and water additions/saltcake dissolution. Because these are planned activities, the frequency without controls was qualitatively determined to be "anticipated." Safety-significant SSCs and/or TSRs are required based on the Risk Bin I result associated with the onsite radiological and toxicological consequences.

- **Deflagration in SST Waste-Intruding Equipment.** Refer to the DST summary above.

- **Deflagration in a Waste Transfer-Associated Structure.** There are two means by which flammable gas can be present in a waste transfer-associated structure. First, flammable gases can enter a structure if it is connected via open piping, drain lines, or risers to an SST, DST, or other waste storage facility. Second, flammable gases would be produced if waste were present in a structure due to a waste transfer misroute or transfer line failure. In the absence of controls, the flammable gas concentration could exceed the LFL via either means.

  The frequency and consequences of flammable gas deflagrations in typical waste transfer-associated structures (e.g., pump pits, valve pits) are qualitatively addressed in DSA Section 3.3.2.4.4. The frequency of a postulated flammable gas deflagration in a waste transfer-associated structure without controls depends on the source of the flammable gas hazard (e.g., flammable gases entering from a connected tank, flammable gases generated by waste from a new or past leak) with the highest frequency being "anticipated." The radiological consequences to the onsite worker and toxicological consequences to the offsite public are qualitatively determined to be "low," and the toxicological consequences to the onsite worker are qualitatively determined to be "moderate." Safety-significant SSCs and/or TSRs are required based on the Risk Bin II result associated with the onsite toxicological consequences.

4.1.1.2 Modified Sluicing Operations Hazardous Conditions

The HAZOP for modified sluicing systems and operations described in Chapter 3.0 identified potential hazardous conditions that could result in a flammable gas deflagration. However, the only hazardous conditions identified that require additional safety evaluation are associated with the induced release of flammable gases caused by modified sluicing operations in SSTs. The other identified flammable gas hazardous conditions are addressed by the existing DSA hazard and accident analyses and derived controls (i.e., safety SSCs and/or TSRs), and no further evaluation is required. This section, therefore, only evaluates induced GRE flammable gas hazardous conditions in SSTs caused by modified sluicing operations.

During modified sluicing operations in SSTs flammable gases retained in the waste will be released. Trapped gases exist as small bubbles in the interstices of the solid waste matrix, separated from other bubbles and the headspace by interstitial liquid. During modified sluicing operations, drainage of the interstitial liquid from the undisturbed solid waste matrix, dissolution of the saltcake matrix, and mechanical break-up of the solid waste matrix will release trapped gases. Draining reduces the tank interstitial liquid level, releasing any entrained gas bubbles. Waste dissolution involves liquid addition causing saltcake to dissolve, thus releasing any trapped gas. Mechanical disturbance of the waste such as by sluicing, vortex action, or pump suction and return, causes shear forces on the solid waste matrix releasing entrained gas bubbles. All three of these gas release mechanisms (draining, dissolution, and mechanical disturbance) individually and collectively contribute to the flammable gas concentration within the SST headspace during modified sluicing operations.

PNNL-14271, *Flammable Gas Release Estimates for Modified Sluicing Retrieval of Waste from Selected Hanford Single-Shell Tanks*, evaluates the potential for induced GRE flammable gas hazards in SSTs during modified sluicing operations. Models developed to estimate retained gas releases, conservative retained gas inventory estimates, tank data, and anticipated waste retrieval rates were used to evaluate the dissolution and erosion of saltcake by water jets impinging on the waste surface, and the drainage of interstitial liquids from saltcake and the dissolution of saltcake by unsaturated liquids during a shutdown of modified sluicing operations.

The results of the evaluation in PNNL-14271 show that under conservative assumptions the flammable gas concentration in the SST headspace can rapidly approach 25% of the LFL when the tank is passively ventilated (e.g., for SST 241-S-112, 25% of the LFL is reached in just over 8 hr). Use of a portable exhauster within the assumed operating range of 270 to 475 ft^3/min prevents the SST headspace from reaching 25% of the LFL. Conservative estimates of gas release volumes after modified sluicing shutdown show that SST headspace flammable gas concentrations could exceed 100% of the LFL assuming no ventilation, complete interstitial drainage, and release of all retained gas from the region above the final interstitial liquid level. The free liquid inventories in an SST (i.e., maximum allowable tank inventory of process water and minimum level of liquid in the central pool) that would prevent exceeding 100% of the LFL in the SST headspace after modified sluicing shutdown are calculated.

4.1.1.3 Accident Consequence Comparison

The consequences of a flammable gas deflagration caused by an induced GRE during modified sluicing operations are bounded by the DSA analysis of SST deflagrations (i.e., "moderate" onsite radiological consequences, "low" offsite toxicological consequences, and "moderate" onsite toxicological consequences). That is, material source terms, release fractions, and airborne respirable fractions are bounded by the DSA analysis for deflagration in an SST.

4.1.1.4 Accident Frequency Comparison

Flammable gas deflagrations due to induced GRE flammable gas hazardous conditions caused by modified sluicing operation in SSTs was qualitatively determined to be "anticipated" which is the same as the frequency of the induced GRE accident scenario in the DSA.

4.1.1.5 Accident Risk Bin Results Without Controls

Based on the risk binning methodology presented in the DSA, an induced GRE flammable gas deflagration accident caused by modified sluicing operations in an SST with an "anticipated" frequency results in a Risk Bin I for onsite radiological and toxicological (moderate consequence) and Risk Bin III for offsite toxicological (low consequence).

4.1.1.6 Safety-Significant SSCs and TSR Controls

Based on the hazard evaluation of postulated induced GRE flammable gas hazards in SSTs caused by modified sluicing operations, safety-significant SSCs and/or TSRs are required to protect the onsite (and facility) worker. For induced GRE flammable gas hazards in the DSA, there are no identified safety-significant SSCs, but the following TSR is established to prevent induced GRE flammable gas hazards.

A flammable gas concentration control point of ≤ 25% of the LFL shall be implemented for all tank farm facilities during activities that can induce a gas release that can achieve 100% of the LFL without the use of flammable gas concentration controls (e.g., active or manually configured passive ventilation, process controls, flammable gas concentration monitoring and proceduralized actions). Any combination of flammable gas concentration controls may be used to maintain the flammable gas concentration ≤ 25% of the LFL. Flammable gas concentration controls shall be monitored on a sufficient frequency to ensure that appropriate actions are taken for conditions > 25% of the LFL.

Flammable gas concentration controls shall be documented in a process control plan such that the flammable gas concentration is maintained ≤ 25% of the LFL. A process control plan will not be required for saltwell pumping.

If the concentration of flammable gas is > 25% of the LFL:

1. Immediately stop all activities in and directly above the affected tank, except for the following:

   a. Flammable gas sampling/monitoring.
   b. Deenergizing, removing, or stopping the use of equipment that does not meet ignition controls.
   c. Actions to reduce the flammable gas concentration.

2. Prior to the concentration of flammable gas exceeding 60% of the LFL:

a. Stop all activities in enclosed spaces connected to the affected tank headspace, except for flammable gas sampling/monitoring and actions to reduce the flammable gas concentration.

b. Deenergize, remove, or stop use of equipment that does not meet ignition controls in the affected tank headspace and connected enclosed spaces.

The flammable gas concentration controls selected as an acceptable method to implement this TSR for modified sluicing operations are :

1. Develop process controls such that the anticipated flammable gas concentration in Waste Group B SSTs is maintained ≤ 25% of the LFL for modified sluicing operations. (Note: Active ventilation may be used to maintain the flammable gas concentration ≤ 25% of the LFL.)

2. Periodically monitor the flammable gas concentration in the tank headspace to verify that it is ≤ 25% of the LFL during modified sluicing operations in Waste Group B SSTs. If the flammable gas concentration is > 25% of the LFL, take the actions prescribed in the TSR. (Note: Actions taken if the flammable gas concentration is > 25% of the LFL include stopping modified sluicing operations.)

Note: There are no Waste Group A SSTs, and there is no induced GRE flammable gas hazard in Waste Group C SSTs (i.e., there is insufficient retained gas to achieve 100% of the LFL if 100% of the retained gas was instantaneously released) and, therefore, induced GRE flammable gas concentration controls are not required.

The specific process controls to maintain the flammable gas concentration ≤ 25% of the LFL (e.g., active ventilation) and the periodicity for monitoring the flammable gas concentration in the tank headspace will be specified in the process control plan. The flammable gas monitoring frequency will be based on a conservative evaluation of the time for the flammable gas concentration to increase by 25% of the LFL (e.g., PNNL-14271). For example, based on the evaluation of SST 241-S-112 in PNNL-14271 (see Section 4.1.1.2), the frequency of flammable gas monitoring would be at least once every 8 hr. Periodic flammable gas monitoring would also continue after shutdown of modified sluicing operations until a downward trend is observed that demonstrates that 25% of the LFL will not be exceeded.

In addition to the above flammable gas concentration controls, if active ventilation is required to maintain the flammable gas concentration ≤ 25% of the LFL, process controls will be developed such that the flammable gas concentration is maintained ≤ 100% of the LFL following the loss of active ventilation and shutdown of modified sluicing operations. The specific process controls (e.g., maximum allowable tank inventory of process water and minimum level of liquid in the central pool derived in the PNNL-14271 evaluation) will be specified in the process control plan.

4.1.1.7 Conclusions

Potential flammable gas hazards caused by modified sluicing operations are addressed and bounded by the DSA representative accidents. Postulated flammable gas accidents are also acceptably controlled by existing safety SSCs and TSRs, and no additional controls are necessary. Specific flammable gas concentration controls to implement the existing TSR requirement for induced flammable gas hazard controls have been defined.

4.1.2 Criticality

4.1.2.1 DSA Representative Accident.

The DSA-related representative accident is 02 (Candidate Accident 01), Nuclear Criticality. The technical basis for the nuclear criticality safety of waste stored in underground tanks at the Hanford Site is summarized in DSA Section 3.3.2.4.2, "Nuclear Criticality." The DSA analysis postulated a mistransfer of waste from the Plutonium Finishing Plant that was routed to a DST where a criticality occurred.

The DSA indicates that no credible scenario has been identified for a criticality in a waste tank because of normal operations of waste storage. The potential for a criticality as a result of a mistransfer was analyzed. The potential for an accidental criticality without controls was estimated to be "beyond extremely unlikely." The criticality accident onsite radiological and onsite and offsite toxicological consequences are "low" (i.e., < 25 rem, < TEEL-1, and < TEEL-2, respectively). Based on the estimated consequences and qualitative judgment, all the exposure categories were assigned to Risk Bin IV, which typically do not require safety SSC or TSR-level controls. However, one TSR-level control was selected to protect the frequency assumption as described in the DSA.

4.1.2.2 Waste Retrieval System Operations Hazardous Conditions

The modified sluicing waste retrieval system HAZOP concluded the potential for a criticality in the source SST and the receiving DST to remain in Risk Bin IV.

4.1.2.3 Accident Frequency Comparison

RPP-7475, *Criticality Safety Evaluation of Hanford Site Tank Farm Facility*, Section 2.8, "Sludge Retrieval Process Description," describes tank farm waste retrieval operations. Criticality concerns associated with sludge retrieval operations were evaluated in RPP-7475, Section 6.13, "Sludge Retrieval." The tank sludge contains most of the plutonium inventory of the tanks, which could create a criticality concern. Sludge retrieval operations involving waste retrieval modified sluicing operations were evaluated in RPP-7475. It was concluded that criticality due to sludge retrieval operations was not a concern. Sludge retrieval operations were considered to be the same as previously analyzed fluid dynamic sludge systems, specifically mixer pumps, air lift circulators, or sluicing relative to potential to create a criticality. Based on the evaluation in RPP-7475, it is concluded that criticality due to waste retrieval modified sluicing system operations remains "beyond extremely unlikely" without application of controls, and therefore, there is no increase in the frequency of a criticality accident as analyzed in the DSA.

4.1.2.4 Accident Consequence Comparison

The consequence of an unplanned nuclear criticality in a waste tank includes release of fission gases, small amounts of aerosolized plutonium, and tank waste (DSA, Section 3.3.2.4.2.3).

A criticality due to modified sluicing system operations would not result in an increase in SST source term considering the MAR, leak path factors (LPF), airborne release fractions (ARF), or respirable fraction (RF). As such, there would be no increase in potential radiological dose consequences from the SST being retrieved. A qualitative evaluation of the consequences of a nuclear criticality accident is described in RPP-12371, *Technical Basis for the Nuclear Criticality Accident and Associated Represented Hazardous Conditions*. Based on a review of this document, it is concluded that the DSA analysis unit-liter dose (ULD) values bound the ULD values of DST liquids and the ULD of the slurry mixture to be transferred from the 100-series SSTs. As such, the DSA representative accident analysis radiological dose consequences remain bounding for a criticality from modified sluicing system operations.

4.1.2.5 Safety SSCs and TSR Controls

Administrative Control (AC) 5.7, "Safety Management Programs," Section 5.7.2, Program Key Element "a" requires that the safety management programs (SMP) of DSA Chapters 6.0 through 17.0 to be established, implemented, and maintained. Chapter 6.0 of the DSA outlines the criticality safety program, which protects the assumptions on the current configuration of the tank waste with respect to criticality by establishing waste acceptance criteria (e.g., limits on fissile material concentration and alkalinity) for wastes entering the tank farms from outside sources. The criticality safety program also requires that criticality safety evaluations be performed for proposed tank farm operations that could change the form of the fissile material (e.g., dissociation of the fissile material from bound neutron absorbers by acid additions) or the distribution of the fissile material in the tanks (e.g., concentration of the fissile material).

4.1.2.6 Conclusions

A criticality evaluation of modified sluicing waste retrieval system operations concluded that a criticality was not credible. TSR controls are in place to ensure that the assumptions used to derive this conclusion remain valid. As such, the DSA representative accident remains bounding and no additional controls are necessary.

4.1.3 Release from Contaminated Facility

The DSA, Section 3.3.2.4.4, "Release from Contaminated Facility," provides the evaluation of this representative accident. Numerous contaminated areas exist within the tank farm facilities that are susceptible to releasing hazardous material, specifically during a fire. Contamination of tank farm facilities occurs from various operations required to manage tank waste. Contaminated facilities at the tank farms include waste transfer-associated structures (e.g., valve pits, pump pits, diversion boxes, clean-out boxes), 244-CR Vault cells, 242-T Evaporator, etc. The hazard analysis performed for tank farm facilities and operations, including HNF-SD-WM-FHA-020, *Tank Farms Fire Hazards Analysis* (FHA), identify energy sources that could result in the uncontrolled release of radioactive and other hazardous material from contaminated tank farm facilities.

A qualitative evaluation of the frequency, consequences, and risk bin without controls for postulated release accidents from contaminated facilities, and the controls (i.e., safety SSCs and TSRs) selected to prevent or mitigate these previously analyzed accidents, are described in

RPP-13354, *Technical Basis for the Release from Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions*. These qualitative evaluations and the resulting controls for the uncontrolled release of radioactive and other hazardous material from contaminated facilities are addressed in Section 3.3.2.4.4 of the DSA.

4.1.3.1 DSA Representative Accident

A flammable gas deflagration in a waste transfer-associated structure is considered the bounding representative accident for a Release from a Contaminated Facility as discussed in the DSA. In this bounding accident scenario, flammable gases from a connected tank (e.g., DST, SST) or from waste present in the structure accumulate to the LFL and are ignited. Other identified energy sources that could result in uncontrolled releases from waste transfer-associated structures or other contaminated facilities include load-handling (e.g., load drop) accidents, compressed gas system failures, and other fires. Postulated causes of these other fires include electrical fires; fires due to maintenance activities (e.g., cutting, grinding, welding) and transient combustibles; and vehicle fuel fires. The FHA provides a complete description of the hazards investigated.

4.1.3.2 Waste Retrieval System Operations Hazardous Conditions

The waste retrieval modified sluicing system design introduces sluice nozzles and actuators that are hydraulically driven. These hydraulic lines, if ruptured, could leak into a pit and could be subject to internal fires (e.g., electrical or fluid) or exposed to vehicle fuel fires or other external fires (e.g., range fires or lighting initiated fires).

A HAZOP was performed to identify and evaluate potential hazards associated with SST waste retrieval modified sluicing system. The results of the HAZOP were reviewed to determine potential hazardous conditions created by the waste retrieval modified sluicing system and to identify potential hazardous conditions that may not be adequately bounded by current tank farms (DSA) analyzed representative accidents.

Hazardous conditions involving energy sources that could result in the uncontrolled release of radioactive and other hazardous material from contaminated tank farm facilities similar to those associated with the waste retrieval modified sluicing system have previously been considered in the DSA as Representative Accident Number 4 (Candidate Accident 7). A total of 11 hazardous conditions involving releases from contaminated facilities associated with the waste retrieval modified sluicing system operations were identified via the HAZOP process. The hazardous conditions expected during conduct of the waste retrieval modified sluicing system operations are similar to those previously identified in the tank farm operations hazards analysis database, Section 3.3.1.7, "Hazard Analysis Database," with the exception of the additional hydraulic line rupture leaking hydraulic fluid into a pit. Three of these hazardous conditions were identified as having characteristics sufficiently different from the hazardous conditions in the DSA hazard evaluation database to warrant further evaluation (i.e., MODSLUIC-C-031, MODSLUIC-D-003a, and MODSLUIC-D-003b).

4.1.3.3 Accident Frequency Comparison

The frequency of a postulated fire within a contaminated structure without controls is dependent on the cause of the fire. An electrical fire, or fire due to maintenance activities or transient combustibles in a contaminated facility without controls, is also qualitatively estimated as "anticipated" based on operating experience. Since, the DSA estimated frequency for these accident scenarios is already "anticipated" without controls, the uncontrolled accident frequency cannot be increased by modified sluicing waste retrieval system operations. A frequency of "unlikely" however was determined qualitatively for this postulated hazardous condition and therefore bounded by the DSA estimated frequency of "anticipated." "Unlikely" was chosen because the hydraulic fluid is limited to approximately 150 gal and has a high flashpoint (e.g., > 380 °F, and a NFPA Fire Rating of 1).

4.1.3.4 Accident Consequence Comparison

To estimate the potential consequences of a fire in a contaminated facility, the MAR is conservatively assumed in the DSA to be the equivalent of between 10 and 100 L of tank waste with solids fractions ranging from 1% to 10%.

The ARF and RF used to determine the amount of respirable material released during a fire in a contaminated facility are from DOE-HDBK-3010-94, *Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*. An ARF of 0.2 and an RF of 0.3 for an aqueous solution or air-dried salts under a gasoline fire on a surface that is a strong conductor of heat (i.e., metal) are considered to conservatively bound releases from a fire.

Based on the above MAR and release fractions, the total amount of respirable material suspended by a fire in a contaminated facility represented by a waste transfer-associated structure is conservatively estimated to be between a few mL and 2.5 L, depending on the release mechanism. Radiological and toxicological consequences for this material release are estimated using the bounding radiological ULD for all tank wastes from RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*; the bounding toxicological sum of fraction (SOF) values for all tank wastes from RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses*; and the accident analysis methodology described in RPP-13482, *Atmospheric Dispersion Coefficients and Radiological/Toxicological Exposure Methodology for Use in Tank Farms*. For the fire, a conservative release duration of 15 min was assumed for estimating consequences. In addition, the fire analysis included the thermal (buoyant) effects of the fire when determining the atmospheric dispersion coefficients.

The radiological consequences to the onsite worker and toxicological consequences to the offsite public are "low" (< 25 rem, < TEEL-1, and < TEEL-2, respectively) based on the conservative calculations in RPP-13354 for fires in contaminated facilities (see DSA Table 3.3.2.4.4-1).

The waste retrieval modified sluicing system design uses existing tank farm pits with drains. Hence, little to no accumulation of wastes is expected within the pits as a result of a spill or leak. The 42-L of MAR previously analyzed in the DSA is considered bounding for this scenario. Additionally, a review of the waste retrieval modified sluicing system indicates that only a limited amount of combustibles may be available to burn from a hydraulic oil rupture (approximately 150 gal) and the hydraulic oil has a high flashpoint (e.g., > 380 °F, and NFPA

Fire Rating of 1). Therefore, the DSA consequences for a "Release from Contaminated Facility" would remain bounding.

4.1.3.5 Safety SSCs and TSR Controls

Based on the low offsite and onsite consequences, there are no TSR and/or safety SSC controls required for this postulated accident.

4.1.3.6 Conclusions

Based upon this safety evaluation, the DSA representative accident for "Release from Contaminated Facility" adequately bounds the frequency and consequences of similar hazards (e.g., fires) involving the waste retrieval modified sluicing system operations, when considering the application of current TSR controls.

No additional controls are necessary to prevent and/or mitigate releases from contaminated facilities due to waste retrieval modified sluicing operations.

4.1.4 Waste Transfer Leaks

4.1.4.1 DSA Representative Accidents

The DSA representative accidents are the "fine spray into the air" scenario and the "large pipe break into a pit" scenario. The fine spray into the air scenario assumes that a small width crack (the optimal width for producing fine aerosol) has occurred in a waste transfer line, and that waste slurry is spraying into the air under maximum available pump pressure. The large pipe break into a pit scenario assumes that a large pipe break has occurred, and that waste is leaking into an open pit at the maximum flow rate of the transfer pump. DSA Section 3.3.2.4.13, "Waste Transfer Leak," addresses these hazardous conditions. The DSA section also addresses several other accident scenarios, but the fine spray into the air and the large pipe break into a pit scenario are the limiting scenarios. The DSA estimates the frequency of the fine spray into the air scenario to be "unlikely," and the large pipe break into a pit scenario to be "anticipated." The onsite radiological and toxicological guidelines are exceeded for the two representative accident scenarios, and safety SSCs and/or TSR controls are required. The offsite radiological and toxicological guidelines are not exceeded.

4.1.4.2 Waste Retrieval System Operations Hazardous Conditions

The waste retrieval modified sluicing system HAZOP identified numerous hazardous conditions that could occur during modified sluicing system operations that would result in waste transfer leaks. These conditions involve leaks occurring in transfer lines at various locations and in various configurations. All of these scenarios are similar to scenarios already evaluated in DSA Section 3.3.2.4.13. The significant analysis parameters that differ in value between modified sluicing and the existing DSA include ULDs, SOFs, ^{137}Cs and ^{90}Sr concentrations, maximum transfer pump pressure, and maximum transfer pump flow rate. Other parameters significant to the calculation of radiological dose and toxicological exposure values are expected to be the same for modified sluicing and the DSA (e.g., χ/Q atmospheric dispersion values). If the values of all of these parameters for the modified sluicing system are bounded by the values of these parameters used for the current DSA analysis, then it may be concluded that modified sluicing is bounded by the current DSA.

Tables 4-1 and 4-2 provide a comparison of the analysis parameter values for properties associated with the waste (ULDs, SOFs, ^{137}Cs and ^{90}Sr concentrations), and for properties associated with the transfer pumps (maximum transfer pump pressure, and maximum transfer pump flow rate) for modified sluicing and the existing DSA analyses. Table 4-3 provides a comparison of radiological and toxicological consequence values specifically for the Seepex[1] positive displacement pump.

Properties Associated with the Waste

The DSA used values for ULD, SOF, ^{137}Cs concentration and ^{90}Sr concentration that are bounding for all tanks in tank farms. Therefore, it is necessarily true that these values bound those associated with modified sluicing, which are based on the limiting values for 100-series SSTs. However, the DSA assumes that the maximum insoluble solids concentration of a pumped waste stream will be 25 vol%. It has been identified that during modified sluicing, an insoluble solids concentration as high as 30 vol% may be achieved for short periods of time. Consequently, Table 4-1 presents a comparison of analysis parameter values for properties associated with the waste. The data in this table indicate that, even if an insoluble solids concentration of 30 vol% is assumed for modified sluicing, the resulting ULD, SOF, ^{137}Cs concentration, and ^{90}Sr concentration will be bounded by the values assumed in the DSA. The ULD and SOF values for a slurry containing 30 vol% solids are calculated explicitly below and compared to the values assumed in the DSA analysis. The ^{137}Cs and ^{90}Sr concentrations for a 30 vol% slurry are not explicitly calculated because they are well below the DSA values, and would remain below DSA values even for a 100 vol% insoluble solids slurry.

Table 4-1 indicates that waste transfer leak analysis properties associated with the waste to be transferred during modified sluicing are bounded by the values of these properties assumed in the DSA analysis. The other modified sluicing properties that are important for the waste transfer leak analysis are those associated with the waste transfer pumps.

Table 4-1. Properties Associated with the Waste. (2 sheets)

	DSA[(1)]	**Bounding 100-series SSTs (Modified Sluicing)**[(2)] [the bounding tank from which the parameter value is taken is shown below the parameter]
Onsite ULD Liquid	1.0E+3 Sv/L	0 (water)
Onsite ULD Solids	1.9E+5 Sv/L	1.4E+5 Sv/L (AX-104)
Onsite Slurry ULD	4.8E+4 Sv/L (25 vol%)	4.2E+4 (30 vol%)
Offsite ULD Liquid	1.5E+3 Sv/L	0 (water)

[1] Seepex is a registered trademark of Seeberger GmbH and Company, Germany.

Table 4-1. Properties Associated with the Waste. (2 sheets)

	DSA[1]	Bounding 100-series SSTs (Modified Sluicing)[2] [the bounding tank from which the parameter value is taken is shown below the parameter]
Offsite ULD Solids	2.9E+5 Sv/L	1.9E+5 Sv/L (AX-104)
Offsite Slurry ULD	7.4E+4 Sv/L (25 vol%)	5.7E+4 Sv/L (30 vol%)
Onsite SOF Liquid	5.8E+8 (TEEL-2)	0 (water)
Onsite SOF Solids	3.9E+9 (TEEL-2)	6.28E+8 (TEEL-2) (A-102)
Onsite Slurry SOF	1.4E+9 (25 vol%)	1.9E+8 (30 vol%)
Offsite SOF Liquid	7.9E+9 (TEEL-1)	0 (water)
Offsite SOF Solids	3.8E+9 (TEEL-1)	2.21E+9 (TEEL-1) (TY-102)
Offsite Slurry SOF	6.9E+9 (25 vol%)	6.6E+8 (30 vol%)
^{137}Cs Solids	7.0E+10 Bq/L	1.1E+3 uCi/gm[3][4] 7.1E+7 Bq/L (AX-104)
^{137}Cs Liquid	5.9E+10 Bq/L	3.4E+2 uCi/gm[3][4] 2.0E+7 Bq/L (A-102)
^{90}Sr Solids	2.9E+12 Bq/L	4.4E+4 uCi/gm[3][4] 2.9E+9 Bq/L (AX-104)
^{90}Sr Liquid	3.5E+9 Bq/L	4.8E+1 uCi/gm[3][4] 2.2E+6 Bq/L (T-103)

Notes:

DSA = documented safety analysis.
SOF = sum of fractions.
SST = single-shell tank.
TEEL = Temporary Emergency Exposure Limit.
ULD = unit-liter dose.

Note that the supernatant is assumed to be essentially water because of the small amounts of supernatant in the tanks to be sluiced and the high degree of dilution during sluicing.

[1]Onsite radiological data and onsite and offsite toxicological data from RPP-13750, *Waste Transfer Leaks Technical Basis Document*. Offsite radiological data from RPP-14499, *Offsite Radiological Consequence Analysis for the Waste Transfer Leak*.

[2]Radiological data from RPP-5924, *Radiological Source Terms for Tank Farms Safety Analysis*, unless otherwise noted. Toxicological data from RPP-8369, *Chemical Source Terms for Tank Farms Safety Analyses*.

[3]Best Basis Inventory, available at: http://twins.pnl.gov/twins.htm, Pacific Northwest National Laboratory, Richland, Washington.

[4]Conversion of uCi/gm to Bq/L required use of the following density values taken from the Best Basis Inventory:
tank 241-A-102 supernatant density = 1.57 g/ml
tank 241-T-103 supernatant density = 1.2 g/ml
tank 241-AX-104 sludge density = 1.8 g/ml

Properties Associated with the Transfer Pumps

Two types of waste transfer pumps are currently planned for use for modified sluicing. The Lawrence pump configuration consists of an immersible (also referred to as "submersible") pump that provides positive suction head to a vertical inline "booster" pump. These two pumps are centrifugal pumps. This configuration was selected to bound the pump configuration that will be used for modified sluicing because the final pump configuration has not yet been selected.

The other planned transfer pump configuration planned for use during modified sluicing consists of a single Seepex positive displacement pump. A positive displacement pump is especially appropriate for pumping higher solids content waste material.

Table 4-2 compares the transfer pump properties with those assumed in the DSA.

Table 4-2. Properties Associated with the Transfer Pumps.

	DSA	Lawrence centrifugal pump configuration	Seepex positive displacement pump
Max. Flow Rate	790 gal/min	~ 685 gal/min(1)	521 gal/min(4)
Max. Pressure	800 ft (approx. 460 lb/in^2 gauge for 7 vol% insoluble solids waste)	153.5ft + 550.1ft = 703.6ft(2)(3)	480 lb/in^2 gauge(5)

Notes:
DSA = documented safety analysis.
(1) This flow rate is for the Vertical Inline Pump. It is taken from Section 8.3, Test No. T3549, CVI #22668 Supplement No. 147, *Quality Documentation Plan*, Lawrence Pumps, Inc., Lawrence Mass.
(2) 153.5 ft is for the submersible pump. It is taken from Section 8.1, Test No. T3553, CVI #22668 Supplement No. 147, *Quality Documentation Plan*, Lawrence Pumps, Inc., Lawrence Massachusetts.
(3) 550.1 ft is for the Vertical Inline Pump. It is taken from Section 8.3, Test No. T3549, CVI #22668 Supplement No. 147, *Quality Documentation Plan*, Lawrence Pumps, Inc., Lawrence Massachusetts.
(4) This maximum flow rate was calculated based on information from CVI #50253. The derivation of this flow rate is given in an email from Buchanan (2003), *Seepex pump max flow*.
(5) This maximum pressure was estimated by the vendor in an email from Cranford (2003) [Seepex, Inc.], *RE: postulated limiting conditions*. This email has been incorporated into vendor data file CVI #50253.

A composite pump curve is not available for the Lawrence Centrifugal Pump configuration. Therefore, the maximum pressures from the two individual pump curves (i.e., the submersible pump and the vertical inline pump) were added to produce an approximate bounding maximum pressure for the two pumps operating in series. The maximum flow rate for the two pumps operating in series was taken to be the maximum flow rate for the vertical inline pump, since it has the lower maximum flow rate of the two pumps and would therefore be limiting. As Table 4-2 shows, the Lawrence Centrifugal Pump configuration pump parameters are bounded by the pump parameters assumed in the DSA analysis.

The Seepex pump is a positive displacement pump rather than a centrifugal pump and, consequently, it does not have a pump curve like a centrifugal pump. However, the uncontrolled maximum pump flow rate and the uncontrolled maximum pump discharge pressure can be estimated based on the point at which the pump motor is estimated to begin to fail (i.e., for the uncontrolled case, no credit is taken for the pressure relief valve or amperage limits that are normally associated with the pump). Based on vendor data file CVI #50253, the maximum flow rate is calculated to be approximately 521 gal/min (Buchanan, 2003, *Seepex pump max flow*).

This calculation assumes a maximum absorbed horsepower for the pump of 34.5 hp, producing a maximum pump speed of about 650 rpm in a no backpressure condition.

A similar calculation (Cranford, 2003, [Seepex, Inc.], *RE: postulated limiting conditions*, also included in vendor file CVI #50253), suggests the maximum pump pressure is approximately 480 lb/in^2 gauge.

As Table 4-2 indicates, the maximum flow rate for the Seepex pump is bounded by the DSA assumed maximum flow rate, while the maximum pressure may not be bounded. However, recalculation of the bounding onsite and offsite radiological and toxicological consequences using the waste properties from Table 4-1, together with an assumed 480 lb/in^2 gauge pump pressure, produces the following results (Table 4-3).

Table 4-3. Seepex Pump Maximum Pressure Exposure Comparison.

	DSA	**480 lb/in^2 gauge pressure**
Onsite radiological exposure	Moderate risk bin(1)	Moderate risk bin(3)
Onsite toxicological exposure	High risk bin(1)	High risk bin(3)
Offsite radiological exposure	1.4E-1 rem(2)	6.3E-2 rem(3)
Offsite toxicological exposure	Low risk bin(1)	Low risk bin(3)

Notes:

DSA = documented safety analysis.

(1) RPP-13750, *Waste Transfer Leaks Technical Basis Document.*

(2) RPP-14499, *Offsite Radiological Consequence Analysis for the Waste Transfer Leak.*

(3) Based on the same calculational methodology as described for the fine spray accident scenario analyses in RPP-13750 and RPP-14499.

Calculations of the results for 480 lb/in^2 gauge pressure are contained in the following Excel spreadsheets:

Fine Spray 8hr 0% 480 lb/in^2 gauge (9-11-03).xls
Fine Spray 8hr 7% 480 lb/in^2 gauge (9-11-03).xls
Fine Spray 8hr 15% 480 lb/in^2 gauge (9-11-03).xls
Fine Spray 8hr 25% 480 lb/in^2 gauge (9-11-03).xls

Based on the information in Table 4-3, a maximum pump pressure of 480 lb/in^2 gauge would produce consequences that are bounded by the current DSA analysis.

As Cranford (2003) notes, it is possible that a pressure spike greater than 480 lb/in^2 gauge may occur for a short period of time. If the pressure is high enough (on the order of 2,000 lb/in^2 gauge to 3,000 lb/in^2 gauge) and a leak occurs, the offsite evaluation guideline could be exceeded. However, this analysis assumes the leak exists in the form of a fine crack that has optimal width for producing fine spray. If such a crack did occur, it is very likely that it would quickly expand due to the high pressure of the leaking fluid. As the width of the crack increases from the optimal width for spray production, the amount of respirable size aerosol particles produced decreases rapidly. Consequently, it is qualitatively judged that, even if a leak occurred at a pressure much higher than 480 lb/in^2 gauge and a crack occurs that has the optimal width for production of fine aerosol, this crack configuration would not exist for an extended period of time (i.e., 8 hr is assumed in the DSA analysis) and offsite radiological consequences would no challenge guidelines.

Also, it may be noted that the Seepex pump includes a relief valve. No credit is taken for this relief valve when estimating uncontrolled radiological and toxicological consequences. However, this relief valve is considered a defense-in-depth feature for mitigation of accident scenarios involving high pump pressures.

4.1.3.3 Safety SSCs and TSR Controls

The discussion presented in Section 4.1.3.2 indicates that waste transfer leak accident scenarios associated with modified sluicing are bounded by those currently addressed in the DSA. Therefore, the controls specified in the TSRs for the waste transfer leak accident as analyzed in the DSA also provide adequate risk reduction for waste transfer leak accidents associated with modified sluicing operations. The current controls for waste transfer leak accident scenarios specified in the TSRs are as follows:

- LCO 3.1.1, "Transfer Leak Detection Systems"
- LCO 3.1.2, "Backflow Prevention Systems"
- AC 5.7, "Safety Management Programs"
- AC 5.8, "Emergency Preparedness"
- AC 5.11, "Transfer Controls "
- AC 5.12, "Administrative Lock Controls."

Applicable safety-significant SSCs include:

- Transfer Leak Detection Systems
- Hose-in-hose Transfer Line Systems
- Aboveground Transfer System Vehicle Barriers (if used to comply with AC 5.11)
- Service Water Pressure Detection Systems (if used to comply with LCO 3.1.2)
- Backflow Preventers (if used to comply with LCO 3.1.2).

It is assumed in this analysis that all transfer lines used for modified sluicing will be either underground or, if aboveground, will be safety-significant HIHTL systems.

As noted above, the relief valve installed on the Seepex positive displacement pump will be treated as a defense-in-depth feature.

4.1.3.4 Conclusions

The waste transfer leak accident scenarios associated with modified sluicing are bounded by those currently addressed in the DSA. Therefore, the controls specified in the TSRs for the waste transfer leak accident as analyzed in the DSA also provide adequate risk reduction for waste transfer leak accidents associated with modified sluicing operations.

4.2 EVALUATION OF RISK FROM MODFIED SLUICING OF WASTE FOR DSA CANDIDATE ACCIDENTS NOT SELECTED AS REPRESENTATIVE ACCIDENTS

4.2.1 Filtration Failures Leading to Unfiltered Releases

4.2.1.1 DSA Representative Accident

There is no DSA representative accident because HEPA filter failures from exposure to high temperature or pressure were analyzed and binned in Risk Bin III (RPP-13437, *Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release*). The analyses assume an event that results in failure of all prefilters, HEPA filters, and other filters (i.e., high-efficiency mist eliminators and high-efficiency gas adsorbers) present in the ventilation system. It is further assumed that a fraction of the inventory of tank waste accumulated on filters and ventilation system ductwork is released. Failure of the filters results in an unfiltered release that also contributes to the consequences of the event. Consequences of all HEPA filter failure and unfiltered release scenarios evaluated in RPP-13437 fall into the "low" category.

4.2.1.2 Waste Retrieval System Operations Hazardous Conditions

SST modified sluicing waste retrieval systems will retrieve waste from designated tanks and transfer the retrieved waste to the DST system. The SST modified sluicing waste retrieval system is designed to dissolve SST crystallized salt and to mobilize sludge through the application of high pressure water or supernatant spray to break down the waste salt, sludge, and solids and to direct the waste to the intake of a slurry transfer pump for transfer into the DST system. Various SST waste retrieval system sluicing designs may be used.

The SST waste retrieval system sluicing designs employ sluicing nozzles that are installed in the tank headspace via SST risers. The number of sluicing nozzles can vary depending on the amount and location of solidified waste within the SST. The nozzle system is designed to aim pressurized fluid (raw water or supernatant) that will break up, mobilize, and move the sludge and compacted solids slurry to a location where they are picked up by a slurry transfer pump.

The SST modified sluicing HAZOP identified potential SST HEPA failures and unfiltered releases from various initiators such as moisture buildup, dome cracking, vapor condensation resulting in a vacuum, and sluice water evaporation resulting in headspace pressurization.

Sluicing operations have the potential to increase the aerosol content of the headspace beyond what is currently evaluated in the DSA. Therefore the effect of the increased aerosol loading requires further evaluation.

4.2.1.3 Accident Frequency Comparison

Aerosol generation and moisture buildup causing HEPA filter failure has been previously identified and documented in the hazard analysis database. The assigned frequency for these conditions is "anticipated" in RPP-13437. Since that is the highest frequency category, the SST modified sluicing operations cannot exceed this frequency.

4.2.1.4 Accident Consequence Comparison

The source terms (including ULD, ARF, and RF) for HEPA filter failure during SST modified sluicing operations would not be different from those currently considered in RPP-13437, since the waste composition will not change and the HEPA filter loading parameters remain the same.

There are no mechanisms during SST modified sluicing operations that would cause an increase in the radiological dose or toxicological consequences from a HEPA filter failure over that analyzed in support of the DSA (RPP-13437). However, an unfiltered release during modified sluicing operations was postulated to have consequences higher than those evaluated in RPP-13437 because of the high aerosol loading in the headspace of the tank being retrieved.

4.2.1.4.1 Toxicological Consequences of an Unfiltered Release. The aerosol release rate can be calculated as follows:

$$(1{,}000\ ft^3/min)\ (1\ min/60\ sec)\ (28.3\ L/ft^3)\ (2 \times 10^{-8}\ L\ waste/L\ air)$$
$$= 9.43 \times 10^{-6}\ L/sec$$

where:

$1{,}000\ ft^3/min$ is the maximum ventilation exhaust flowrate for a portable exhauster

$28.3\ L/ft^3$ is a conversion factor (Weast 1981, *CRC Handbook of Chemistry and Physics*)

2×10^{-8} L waste/L air is the partition fraction of waste in the headspace air during air lift circulator operation which is a conservative selection since the measured partition fraction during a waste transfer is 2×10^{-9} L waste/L air (RPP-13437).

4.2.1.4.2 Onsite Toxicological Consequences. Calculating the TEEL-2 SOF multiplier for an onsite release assuming 5% SST solids and 95% SST liquids (RPP-13437):

$$(0.95)\ (5.73 \times 10^8) + (0.05)\ (6.28 \times 10^8) = 5.76 \times 10^8$$

where:

5.73×10^8 is the bounding liquid TEEL-2 SOF multiplier for 100-series SSTs (RPP-8369, *Chemical Source Terms for Tank Farms Safety Analysis*)

6.28×10^8 is the bounding solid TEEL-2 SOF multiplier for 100-series SSTs (RPP-8369).

Calculating the onsite moderate toxicological consequences:

Onsite, moderate SOF = (aerosol release rate) (onsite χ/Q) (TEEL-2 SOF multiplier)

Onsite, moderate SOF = $(9.43 \times 10^{-6}\ L/sec)\ (3.28 \times 10^{-2}\ sec/m^3)\ (5.76 \times 10^8)/(1{,}000\ L/m^3)$

$= 1.8 \times 10^{-1}$

where:

$3.28 \times 10^{-2}\ sec/m^3$ is the bounding onsite χ/Q for a ground level release (RPP-13482)

1,000 L/m^3 is a volumetric conversion factor.

4.2.1.4.3 Offsite Toxicological Consequences. Calculating the TEEL-1 SOF multiplier for an offsite release assuming 5% SST solids and 95% SST liquids (RPP-13437):

$$(0.95)\ (3.71 \times 10^9) + (0.05)\ (2.21 \times 10^9) = 3.64 \times 10^9$$

where:

3.71 x 10^9 is the bounding liquid TEEL-1 SOF multiplier for 100-series SSTs (RPP-8369)
2.21 x 10^9 is the bounding solid TEEL-1 SOF multiplier for 100-series SSTs (RPP-8369).

Calculating the offsite moderate toxicological consequences:

Offsite, moderate SOF = (aerosol release rate) (offsite χ/Q) (TEEL-1 SOF multiplier)
Offsite, moderate SOF = (9.43 x 10^{-6} L/sec) (2.22 x 10^{-5} sec/m^3) (3.64 x 10^9)/(1000 L/m^3)
= 7.6 x 10^{-4}

where:

2.22 x 10^{-5} sec/m^3 is the bounding offsite χ/Q for a ground level release (RPP-13482).

4.2.1.4.4 Radiological Consequences of an 8-hr Unfiltered Release. The total release over the 8-hr period can be found by:

$$(9.43 \times 10^{-6}\ \text{L/sec})\ (60\ \text{sec/min})\ (60\ \text{min/h})\ (8\ \text{hr}) = 2.72 \times 10^{-1}\ \text{L}$$

Calculating the onsite ULD for an onsite release assuming 5% SST sludge and 95% supernatant (RPP-13437):

$$(0.95)\ (4.4 \times 10^2\ \text{Sv/L}) + (0.05)\ (1.4 \times 10^5\ \text{Sv/L}) = 7.4 \times 10^3\ \text{Sv/L}$$

where:

4.4 x 10^2 Sv/L is the bounding ULD for supernatant in 100-series SSTs (RPP-5924)
1.4 x 10^5 Sv/L is the bounding ULD for sludge in 100-series SSTs (RPP-5924).

Calculating the onsite radiological dose:

Onsite Dose = (aerosol released) (onsite χ/Q) (onsite ULD) (breathing rate)
Onsite Dose = (2.72 x 10^{-1} L) (5.58 x 10^{-3} sec/m^3) (7.4 x 10^3 Sv/L) (3.33 x 10^{-4} m^3/sec)
= 3.7 x 10^{-3} Sv
= 3.7 x 10^{-1} rem

where:

5.58 x 10^{-3} sec/m^3 is the onsite 8-hr χ/Q including plume meander (RPP-13482)
3.33 x 10^{-4} m^3/sec is the breathing rate (RPP-5924).

It can be seen that the consequences for the unfiltered release accident are below the moderate risk guidelines (1.0 is the toxicological guideline and 25 rem is the radiological guideline). Even when the consequences for the bounding HEPA filter failure are added to the unfiltered release the guidelines are not challenged. The contribution to the toxicological consequences due to high pressure failure of the HEPA filters is 3.1×10^{-3} for onsite and 4.2×10^{-6} for offsite releases while the bounding contribution to the radiological consequences is 2.2×10^{-4} rem (RPP-13437). The resultant risk bin is III for an accident with a frequency of "anticipated."

4.2.1.5 Safety SSCs and TSR Controls

Currently the DSA has no TSR-level controls for HEPA filter failures or unfiltered releases, nor are any additional controls required for SST modified sluicing conditions. Since SST modified sluicing conditions remain Risk Bin III, they do not require the identification of additional controls beyond existing SMPs.

4.2.1.6 Conclusions

Filtration system failure accidents that could be initiated during SST modified sluicing operations are adequately analyzed and bounded by conditions currently identified in the hazards analysis database and the DSA technical basis documents. No additional controls are necessary.

5.0 CONTROLS

Based on the hazard and accident analysis of modified sluicing operations, no new accidents were identified, and the existing DSA analyses were found to be encompassing and bounding. The DSA controls (i.e., safety SSCs and TSRs) were also found to acceptably prevent or mitigate potential hazardous conditions and postulated accidents for modified sluicing operations. Although the waste transfer spray leak accident caused by the high pressures possible with progressive cavity pumps was determined to be bounded by the DSA analysis and mitigated by the selected DSA controls (e.g., waste transfer-associated covers) and additional defense-in-depth feature was identified for this accident scenario. The defense-in-depth feature is the pressure limiter (e.g., pressure relief valve) for progressive cavity pumps that is designed to prevent pressures exceeding the design pressure of the waste transfer system.

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APPENDIX A

TEAM MEMBER ROSTER

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Hazards Analysis Team Meeting Attendance Sheet

Meeting Subject: Modified Sluicing Date 8/19/03

Name	Organization	Phone	Mail Stop
MILTON V. SHULTZ	NS&L		
John Schofield	Retrieval Projects	3-2245	S7-12
MARC A. DANNA	NS+L	373-4045	
MIKE FLASCH	OPERATIONAL READ.	373-4473	
Scott Conrad	ENVIRONMENTAL	373-5976	
Curt Reichmuth	OPS	6-4796	
John Bores	QA	376-8131	R2-87
CARL HANSON	Retrieval Engr.	376-4810	
Tom Ramirez	Retrieval Engr	373-3531	
Kevin Hull	SST Sys ENGR	376-0415	T4-08
BOB CASH	Closure Proj Engr	373-3132	S7-90
Jim HUCKABY	~~Support~~ PNNL	375-3623	
Kevin Sandgren	NS&L	372-0374	S7-90
Bill Zuroff	Design Eng	372-1003	S7-24
Ryan Smith	NS&L	372-1383	S7-90
Joseph M Jones	NS&L	308-0723	R2-12

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APPENDIX B

DEFINITIONS

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Definitions of information listed in Table 3-X and C-1:

- **ID**: The item identification (ID); used to record a unique identifier for the hazardous condition.

- **Node**: The division of a process or activity into discrete segments is called a node. Each node represents a specific part of the process or activity. This division into nodes is designed to facilitate the hazard identification process.

- **Process Variable**: The characteristics of a process, such as flow, pressure, or temperature, which are used to define proper operation.

- **Deviation**: The deviation is the description of the divergence from the desired value for a given process variable, such as "low temperature" to describe temperature below normal or optimum.

- **Hazardous Condition**: The hardware failures, operational faults, or conditions that could result in undesired consequences. The Hazardous Condition is a concise statement combining the Cause, Consequence, and Mode of radioactive material release.

- **Possible Causes of Deviation**: The causes that lead to the deviation from the process variable and resultant Hazardous Condition.

- **Consequence**: The potential consequences that could result from the postulated deviation.

- **Potential Engineered Features**: Potential SSCs are existing engineered features (hardware items) identified by the hazard and operability study (HAZOP) team that have the potential to mitigate or prevent the hazardous condition of concern. The engineered features are candidates for designation as safety-significant items for hazardous conditions that pose a significant threat to the health of facility workers and onsite personnel or safety class for hazards that pose a significant threat to offsite individuals. These items should not be construed as being the "official" controls that would eventually be credited in the safety basis.

- **Potential Administrative Controls**: Technical safety requirements are existing controls identified by the HAZOP team that have the potential to mitigate or prevent the hazardous condition of concern. These items should not be construed as being the "official" administrative features that would eventually be credited in the safety basis.

- **NC Consequence Category (NC Offsite Rad, NC Offsite Tox, NC Onsite Rad, NC Onsite Tox, NC FW Cons)**: The consequence category is a code designator for the level of safety consequence associated with a specific class of receptor, material of concern (radioactive or toxic material), and the hazardous condition. The consequence assignment is a "first cut," qualitative estimate of the safety severity of the consequences assuming no controls are present. The criteria for determining the consequence designation is unique to the receptor. For the Offsite and Onsite receptor the consequence designators are low (L), moderate (M), and high (H). The facility worker (FW) is assigned a Y or N based on whether the postulated event is estimated to result in severe injury or death. Y indicates there is a potential for significant FW impact and N indicates no potential. Table B-1 summarizes the criteria for Offsite receptors, Onsite receptors, and facility workers:

Table B-1. Consequence Levels and Risk Evaluation Guidelines.

Consequence level	Offsite public	Onsite co-located worker	Site facility worker
High	Considerable offsite impacts on people or the environs. >25 rem TEDE or >ERPG-2/TEEL-2	Considerable onsite impacts on people or the environs. >100 rem TEDE or >ERPG-3/TEEL -3	All facility worker hazards are assessed for prompt death or serious injury or significant radiological or chemical exposure.
Moderate	Only minor offsite impact on people or the environs. 1 rem TEDE or >ERPG-1/TEEL-1	Considerable onsite impact on people or the environs. 25 rem TEDE or >ERPG-2/TEEL-2	
Low	Negligible offsite impact on people or the environs. <1 rem or <ERPG-1/TEEL-1	Minor onsite impact on people or the environs. <25 rem or <ERPG-2/TEEL-2	

Notes:
ERPG = emergency response planning guideline.
TEDE = total effective dose equivalent.
TEEL = Temporary Emergency Exposure Limit.

- **ENV Cons.** The environmental consequence ranking is a "first cut," qualitative estimate of the environmental severity of the hazardous condition assuming no controls are present. The following system is used:

  E0 No significant environmental effect outside the facility confinement systems.

  E1 Limited environmental discharge of hazardous material outside the facility.

  E2 Large environmental discharge of hazardous material within the plant site boundary.

  E3 Significant environmental discharges of hazardous material outside the plant site boundary.

- **NC Frequency**: The NC frequency is a "first cut," qualitative estimate of the likelihood of the hazardous condition assuming no controls are present. The following system is used:

A Events that are expected to occur one or more times during the lifetime of the facility, categorized as "anticipated" events. The frequency range associated with this category is > 1E-02/yr.

U Events that could occur during the lifetime of the facility, but with low probability. Such events are categorized as "unlikely" and fall in the range of 1E-04/yr to 1E-02/yr.

EU Events not expected to occur during the lifetime of the facility, categorized as "extremely unlikely." The frequency range associated with this category is 1E-06/yr to 1E-04/yr.

BEU Events categorized as "beyond extremely unlikely," with a frequency less than 1E-06/yr. Events in this category (such as meteor strike) are so unlikely they generally do not require special controls.

- **Remarks**: Miscellaneous observations or clarifying comments for a given item.

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APPENDIX C

HAZOP TABLE

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Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
MODSLUIC-K-001	01X	Radioactive fission product gases	Release of ionizing radiation and fission product gas from SST to the atmosphere due to criticality in the tank	Excessive solids in slurry flow towards transfer pump	Release of radioactive gases and direct radiation (neutrons)	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: RPP-7475, Rev. 1, Criticality Safety Evaluation of Hanford Tank Farms Facility, demonstrates that a criticality accident in stored tank waste at the Tank Farms facility is an incredible event due to the form (alkaline chemistry) or distribution (associated with neutron absorbers) of the fissile material in tank wastes.	Basis for NC Offsite Rad and Tox consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Onsite Rad and Tox Worker consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Facility Worker consequence: Facility worker consequences are judged to be not significant based on the amount of soil providing shielding over the tanks, the shielding provided by the waste since any criticality will occur within the waste, and the fact that although fission product gases are produced as a result of a criticality, the quantity is small in comparison to the radioactive constituents of the waste.	A-1-a	E1
MODSLUIC-K-002	01X	Radioactive fission product gases	Release of ionizing radiation and fission product gas from SST to the atmosphere due to criticality in the tank	Material reaches critical mass/geometry during sluicing activities	Release of radioactive gases and direct radiation (neutrons)	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: RPP-7475, Rev. 1, Criticality Safety Evaluation of Hanford Tank Farms Facility, demonstrates that a criticality accident in stored tank waste at the Tank Farms facility is an incredible event due to the form (alkaline chemistry) or distribution (associated with neutron absorbers) of the fissile material in tank wastes.	Basis for NC Offsite Rad and Tox consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Onsite Rad and Tox Worker consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Facility Worker consequence: Facility worker consequences are judged to be not significant based on the amount of soil providing shielding over the tanks, the shielding provided by the waste since any criticality will occur within the waste, and the fact that although fission product gases are produced as a result of a criticality, the quantity is small in comparison to the radioactive constituents of the waste.	A-1-a	E1
MODSLUIC-K-003	01X	Radioactive fission product gases	Release of ionizing radiation and fission product gas from SST to the atmosphere due to	Accumulation of material in the pump until critical mass conditions are	Radioactive gas release through ventilation system and worker exposure	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: RPP-7475, Rev. 1, Criticality Safety Evaluation of Hanford	Basis for NC Offsite Rad and Tox consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a	A-1-a	E1

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
			criticality in the progressive cavity pump	met	to high energy neutron radiation											Tank Farms Facility, demonstrates that a criticality accident in stored tank waste at the Tank Farms facility is an incredible event due to the form (alkaline chemistry) or distribution (associated with neutron absorbers) of the fissile material in tank wastes.	scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Onsite Rad and Tox Worker consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Facility Worker consequence: Facility worker consequences are judged to be not significant based on the amount of soil providing shielding over the tanks, the shielding provided by the waste since any criticality will occur within the waste, and the fact that although fission product gases are produced as a result of a criticality, the quantity is small in comparison to the radioactive constituents of the waste.		
MODSLUIC-K-004	01X	SST waste and fission product gases	Release of radioactive and other hazardous materials from SST to atmosphere due to unplanned nuclear criticality	Sluicing selectively removes neutron poisons resulting in criticality, steam generation	Release of neutrons radiation, radioactive fission gases	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: RPP-7475, Rev. 1, Criticality Safety Evaluation of Hanford Tank Farms Facility, demonstrates that a criticality accident in stored tank waste at the Tank Farms facility is an incredible event due to the form (alkaline chemistry) or distribution (associated with neutron absorbers) of the fissile material in tank wastes.	Basis for NC Offsite Rad and Tox consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Onsite Rad and Tox Worker consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Facility Worker consequence: Facility worker consequences are judged to be not significant based on the amount of soil providing shielding over the tanks, the shielding provided by the waste since any criticality will occur within the waste, and the fact that although fission product gases are produced as a result of a criticality, the quantity is small in comparison to the radioactive constituents of the waste.	A-1-a	E1
MODSLUIC-K-005	01X	Radioactive fission gases	Release of ionizing radiation and radioactive gas from DST receiving tank to the atmosphere due to criticality	Waste distributor or dropleg piles or concentrates solids in one place resulting in critical mass	Radioactive and other hazardous materials released to atmosphere	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: RPP-7475, Rev. 1, Criticality Safety Evaluation of Hanford Tank Farms Facility, demonstrates that a criticality accident in stored tank waste at the Tank Farms facility is an incredible event due to	Basis for NC Offsite Rad and Tox consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Onsite Rad and Tox Worker consequence:	A-1-a	E1

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																the form (alkaline chemistry) or distribution (associated with neutron absorbers) of the fissile material in tank wastes.	Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Facility Worker consequence: Facility worker consequences are judged to be not significant based on the amount of soil providing shielding over the tanks, the shielding provided by the waste since any criticality will occur within the waste, and the fact that although fission product gases are produced as a result of a criticality, the quantity is small in comparison to the radioactive constituents of the waste.		
MODSLUIC-K-006	01X	Fission product gases and aerosols produced from criticality	Release of radioactive material due to criticality	Addition of dissolution water to waste causes concentration of fissile material or removal of poisons resulting in criticality	Release of fission product gases and ionizing radiation to the atmosphere	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: RPP-7475, Rev. 1, Criticality Safety Evaluation of Hanford Tank Farms Facility, demonstrates that a criticality accident in stored tank waste at the Tank Farms facility is an incredible event due to the form (alkaline chemistry) or distribution (associated with neutron absorbers) of the fissile material in tank wastes.	Basis for NC Offsite Rad and Tox consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Onsite Rad and Tox Worker consequence: Consequences are "low" because nuclear criticality event is based on 2.8 E18 fissions which produces very small quantities of aerosols and fission product gases. For evaluation purposes, a scoping calculation for a presumed nuclear criticality accident was performed and documented in RPP-12371, Technical Basis for the Nuclear Criticality Representative Accident and Associated Represented Hazardous Conditions. Basis for NC Facility Worker consequence: Facility worker consequences are judged to be not significant based on the amount of soil providing shielding over the tanks, the shielding provided by the waste since any criticality will occur within the waste, and the fact that although fission product gases are produced as a result of a criticality, the quantity is small in comparison to the radioactive constituents of the waste.	A-1-a	E1
MODSLUIC-B-001	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration resulting from water intrusion (induced GRE)	Gas release event (GRE) induced by large water intrusion (misroute) into tank with ignition of flammable gas (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	EU	L	IV	L	IV	M	III	M	III	Y	Basis for NC Frequency: The frequency is qualitatively judged to be "extremely unlikely" based on the likelihood of a water intrusion into an SST that causes sufficient gas to be released to cause the flammable gas concentration in the tank headspace to exceed 100 percent of the LFL.	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document."	A-1-a	E2

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																	Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.		
MODSLUIC-C-006	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during sluicing (induced GRE)	Sluicer jet impinges on solids releasing a region of retained flammable gas (ignition source assumed) (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	M	I	M	I	Y	Basis for NC Frequency: As discussed in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tanks (SST) Modified Sluicing Waste Retrieval System," the frequency of a flammable gas deflagration due to an induced GRE was qualitatively determined to be "anticipated" because modified sluicing operations are capable of releasing retained gas.	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.	A-1-a	E2
MODSLUIC-C-007	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during sluicing (induced GRE)	Sluicing nozzle strikes object when being indexed causing spark and ignition of flammable gas (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	M	I	M	I	Y	Basis for NC Frequency: As discussed in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tanks (SST) Modified Sluicing Waste Retrieval System," the frequency of a flammable gas deflagration due to an induced GRE was qualitatively determined to be "anticipated" because modified sluicing operations are capable of releasing retained gas.	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.	A-1-a	E2
MODSLUIC-C-008	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during sluicing (induced GRE)	Sluice jet moves debris causing spark and flammable gas ignition (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	M	I	M	I	Y	Basis for NC Frequency: As discussed in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tanks (SST) Modified Sluicing Waste Retrieval System," the frequency of a flammable gas deflagration due to an	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence:	A-1-a	E2

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																induced GRE was qualitatively determined to be "anticipated" because modified sluicing operations are capable of releasing retained gas.	The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.		
MODSLUIC-C-009	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during sluicing (induced GRE)	Hydraulic reaction force of jet bends sluicing mechanism against riser causing friction when indexing and ignition of flammable gas (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	M	I	M	I	Y	Basis for NC Frequency: As discussed in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tanks (SST) Modified Sluicing Waste Retrieval System," the frequency of a flammable gas deflagration due to an induced GRE was qualitatively determined to be "anticipated" because modified sluicing operations are capable of releasing retained gas.	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.	A-1-a	E2
MODSLUIC-C-018	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during dissolution water addition (induced GRE)	Spark from impact type spray head causes flammable gas ignition, flammable gas assumed present (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	M	I	M	I	Y	Basis for NC Frequency: As discussed in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tanks (SST) Modified Sluicing Waste Retrieval System," the frequency of a flammable gas deflagration due to an induced GRE was qualitatively determined to be "anticipated" because modified sluicing operations are capable of releasing retained gas.	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.		E2
MODSLUIC-F-007	05X	SST headspace aerosols,	Release of radioactive and other hazardous	Additional aerosols cause premature	Release of radioactive and other hazardous	A	L	III	L	III	M	I	M	I	Y	Basis for NC Frequency: As discussed in RPP-	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-	A-1-a	E2

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
		filter loading, and SST waste	materials from SST to the atmosphere due to flammable gas deflagration during dissolution water addition (induced GRE)	plugging of HEPA filter and buildup of hydrogen concentration in dome space with ignition source resulting in flammable gas deflagration (GRE hazard)	materials to the atmosphere											17965, "Generic Safety Evaluation of the Single-Shell Tanks (SST) Modified Sluicing Waste Retrieval System," the frequency of a flammable gas deflagration due to an induced GRE was qualitatively determined to be "anticipated" because modified sluicing operations are capable of releasing retained gas.	13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.		
MODSLUIC-F-008	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during dissolution water addition (induced GRE)	Aerosols generated during water addition cause plugging of HEPA filter and release of hydrogen pocket with ignition source resulting in flammable gas deflagration (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	BEU	L	IV	L	IV	M	IV	M	IV	Y	Basis for NC Frequency: The frequency is "beyond extremely unlikely" because pockets of gas in the SST waste are insufficient in size to cause the flammable gas concentration in the tank headspace to exceed 100 percent of the LFL.	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.	A-1-a	E2
MODSLUIC-H-001	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during waste recovery (induced GRE)	High waste temperature in SST during retrieval causes a steam bump, which induces a flammable gas release/ignition (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	BEU	L	IV	L	IV	M	IV	M	IV	Y	Basis for NC Frequency: The frequency is "beyond extremely unlikely" because tank or steam bumps are not credible in SSTs (see RPP-6213, "Hanford Waste Tank Bump Accident & Consequence Analysis").	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document."	A-1-a	E2

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																	Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.		
MODSLUIC-H-002	05X	SST headspace aerosols, filter loading, and SST waste	Release of radioactive and other hazardous materials from SST to the atmosphere due to flammable gas deflagration during waste recovery (induced GRE)	Temperature out of specification for waste retrieval causes a steam bump when level is lowered resulting in release of flammable gas (GRE hazard)	Release of radioactive and other hazardous materials to the atmosphere	BEU	L	IV	L	IV	M	IV	M	IV	Y	Basis for NC Frequency: The frequency is "beyond extremely unlikely" because tank or steam bumps are not credible in SSTs (see RPP-6213, "Hanford Waste Tank Bump Accident & Consequence Analysis").	Basis for NC Offsite Consequence: The "low" offsite radiological consequence is based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident." The "low" offsite toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Onsite Consequence: The "moderate" onsite worker radiological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." The "moderate" onsite worker toxicological consequence was qualitatively assigned based on scoping calculations contained in RPP-13510, "Flammable Gas Technical Basis Document." Basis for NC Facility Worker Consequence: The "Yes" for potential significant facility worker consequences was qualitatively assigned based on the physical injury that could potentially result from a flammable gas deflagration.	A-1-a	E2
MODSLUIC-C-030	06X	SST headspace aerosols and filter loading	Release of radioactive and other hazardous materials from SST to atmosphere due to water vapor plugging HEPA filter and causing failure from high delta-pressure (active ventilation)	Dissolution water heating system temperature control fails and water temperature reaches point where high temperature dissolution water flashes to steam at sprinkler nozzle causing additional moisture, plugging of the HEPA filter and HEPA filter failure	Release of radioactive and other hazardous materials to the atmosphere	U	L	III	L	III	L	III	L	III	N	Basis for NC frequency: Dissolution water heating system is not expected to supply water at temperatures exceeding the boiling point. The event frequency is therefore assumed to be "unlikely."	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-17965, "Generic Safety Evaluation of the Single- Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System."	B-1-a	E1
MODSLUIC-E-002	06X	DST headspace aerosols and HEPA filter loading.	Release of radioactive and other hazardous materials from the DST receiver tank ventilation system to the atmosphere	Compressed air used to blow down transfer line exceeds the HEPA filter capacity in the	Release of radioactive and other hazardous materials to the atmosphere	EU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: Compressed air supply provides air at a much lower flow rate than the 1000 CFM HEPA filter capacity. Therefore the frequency was assumed	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based	B-1-a	E1

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
			due to HEPA filter failure due to high pressure	receiver tank causing filter failure and release of contaminants												to be "extremely unlikely."	on calculations documented in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release." Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release."		
MODSLUIC-F-002	06X	SST headspace aerosols and HEPA filter loading.	Release of radioactive and other hazardous materials from SST to atmosphere due to aerosol generation plugging HEPA filter and causing failure from high delta-pressure	Sluicer malfunctions resulting in excessive aerosol generation in head space and release through failed HEPAs caused by HEPA plugging and high differential pressure	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	L	III	L	III	N	Basis for NC frequency: Sluicer malfunction could be due to human error (e.g., improper installation). Human errors are "anticipated" events.	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-17965, "Generic Safety Evaluation of the Single- Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System."	B-1-a	E1
MODSLUIC-G-003	06X	DST HEPA filter loading and headspace aerosols.	Release of radioactive and other hazardous materials from receiving DST to atmosphere due to aerosol generation plugging HEPA filter and causing failure from high delta-pressure	Heat loading from incoming waste causes aerosol generation that results in loading of receiving DST HEPA filters, which fail by high differential pressure	Release of radioactive and other hazardous materials to the atmosphere	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: Incoming SST waste (even at high solids loading) does not contain sufficient heat load to result in self-boiling, much less cause boiling in the receiving tank. Therefore the frequency assigned was "beyond extremely unlikely."	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release." Basis for NC Facility Worker consequence:	B-1-a	E1

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																	The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failures Leading to Unfiltered Release."		
MODSLUIC-C-031	07X	Contamination from pit	Release of radioactive and other hazardous waste from an SST pit to the atmosphere due to hydraulic fluid fire in the pit	Rupture of a hydraulic line to the sluicing articulation actuators leaks into an SST pit and is ignited releasing contamination in the pit	Release of radioactive and other hazardous materials to the atmosphere from the SST heel pit	U	L	III	L	III	L	III	L	III	N	Basis for NC frequency: The "unlikely" frequency is based on the postulated accident scenario that requires ignition of high flash point hydraulic oil in a pit. For the oil to ignite, there would have to be a high temperature source in the pit that could raise the bulk temperature of the oil above the flash point. Sparks are not sufficient to ignite the oil.	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on qualitative comparison of the characteristics of a hydraulic oil fire in a pit with calculations documented in RPP-13354, "Technical Basis for the Release From Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions." Hydraulic oil does not have burn characteristics that are more energetic than what has been evaluated for gasoline or diesel fuel. Basis for NC Onsite Worker consequence: The "low" onsite worker radiological and toxicological consequences are based on qualitative comparison of the characteristics of a hydraulic oil fire in a pit with calculations documented in RPP-13354, "Technical Basis for the Release From Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions." Hydraulic oil does not have burn characteristics that are more energetic than what has been evaluated for gasoline or diesel fuel. Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is based on expected worker response (self-evacuation).	A-1-a	EI
MODSLUIC-D-003a	07X	Contamination in the pit	Release of radioactive other hazardous materials from an SST pit to the atmosphere due to hydraulic fluid fire in the pit	Rupture of a hydraulic line to the sluice nozzle indexer leaks into an SST pit and is ignited releasing contamination in the pit	Release of contamination from the heel pit	U	L	III	L	III	L	III	L	III	N	Basis for NC frequency: The "unlikely" frequency is based on the postulated accident scenario that requires ignition of high flash point hydraulic oil in a pit. For the oil to ignite, there would have to be a high temperature source in the pit that could raise the bulk temperature of the oil above the flash point. Sparks are not sufficient to ignite the oil.	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on qualitative comparison of the characteristics of a hydraulic oil fire in a pit with calculations documented in RPP-13354, "Technical Basis for the Release From Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions." Hydraulic oil does not have burn characteristics that are more energetic than what has been evaluated for gasoline or diesel fuel. Basis for NC Onsite Worker consequence: The "low" onsite worker radiological and toxicological consequences are based on qualitative comparison of the characteristics of a hydraulic oil fire in a pit with calculations documented in RPP-13354, "Technical Basis for the Release From Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions." Hydraulic oil does not have burn characteristics that are more energetic than what has been evaluated for gasoline or diesel fuel.	A-1-a	EI

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																	Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is based on expected worker response (self-evacuation).		
MODSLUIC-D-003b	07X	Contamination in the pit	Release of radioactive other hazardous materials from an SST pit to the atmosphere due to hydraulic fluid fire in the pit	Rupture of a hydraulic line to the transfer pump drive motor leaks into an SST pit and is ignited releasing contamination in the pit	Release of contamination from the heel pit	U	L	III	L	III	L	III	L	III	N	Basis for NC frequency: The "unlikely" frequency is based on the postulated accident scenario that requires ignition of high flash point hydraulic oil in a pit. For the oil to ignite, there would have to be a high temperature source in the pit that could raise the bulk temperature of the oil above the flash point. Sparks are not sufficient to ignite the oil.	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on qualitative comparison of the characteristics of a hydraulic oil fire in a pit with calculations documented in RPP-13354, "Technical Basis for the Release From Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions." Hydraulic oil does not have burn characteristics that are more energetic than what has been evaluated for gasoline or diesel fuel. Basis for NC Onsite Worker consequence: The "low" onsite worker radiological and toxicological consequences are based on qualitative comparison of the characteristics of a hydraulic oil fire in a pit with calculations documented in RPP-13354, "Technical Basis for the Release From Contaminated Facility Representative Accident and Associated Represented Hazardous Conditions." Hydraulic oil does not have burn characteristics that are more energetic than what has been evaluated for gasoline or diesel fuel. Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is based on expected worker response (self-evacuation).	A-1-a	E1
MODSLUIC-C-013	18AX	Tank waste	Release of radioactive other hazardous materials from tank SST to the soil and aerosol release to the atmosphere due to steam bump in liner gap	High pressure sluice induces movement of debris present in waste which impact and breaches the tank liner resulting in water leakage into liner gap, steam formation and bump breaching tank bottom	Below grade radioactive liquid and hazardous liquid release; large steam bump aerosol release to atmosphere	BEU	L	IV	L	IV	L	IV	M	IV	N	NC Frequency Basis: Tank bump resulting from water intrusion behind an SST liner is judged to have a frequency "beyond extremely unlikely. The frequency is based on the fact that a heat load of > 11.3 kW is required to achieve waste temperatures that exceed the saturation temperature of water (RPP-6213). Only four SSTs (241-A-104, 241-AX-104, 241-C-103, and 241-C-107) have heat loads in excess of 11.3 kW (RPP-5926). Current waste temperature data shows that these tanks are well below the saturation temperature of	Basis for NC Offsite consequence: The "low" offsite radiological consequences are calculated in RPP-12395, "Offsite Radiological Consequence Analysis for the Bounding Tank Failure Due to Excessive Loads Accident," which bounds the tank bump accident. The "low" offsite toxicological consequences are calculated in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failure Leading to an Unfiltered Release." Basis for NC Onsite Worker consequence: The "low" onsite radiological consequences are calculated in RPP-13438, "Technical Basis for the Tank Bump Representative Accident and Associated Hazardous Conditions." The "low" onsite toxicological consequences are calculated in RPP-13437, "Technical Basis Document for Ventilation System Filtration Failure Leading to an Unfiltered Release." Basis for NC Facility Worker consequence: The facility worker consequences are judged to not be significant based on the "low" toxicological consequences of the onsite worker.	C-3-b	E2

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
																water. The highest temperature found in these four tanks is 76C (168.8F) (241-A-104). These tanks have been under passive cooling conditions for many years and show no trend of increasing temperature. Since the temperature is substantially below the saturation of water there is no possibility of steam bubble formation behind the tank liner no matter what quantity of water is involved.			
MODSLUIC-C-001	18BX	SST headspace aerosols	Release of radioactive other hazardous materials from SST to atmosphere due to tank dome breach from impact	During sluicing operations, sluicer moves debris in waste impacting drop leg or in tank equipment, which breaches dome causing unfiltered release (assumes ventilation system failure)	Waste release to atmosphere	EU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: Even if large pieces of debris are present in the tank, the sluicer will not provide sufficient motive force to cause the debris to impact the drop leg or in tank equipment vigorously enough to cause dome breach. Therefore the frequency was assumed to be "extremely unlikely."	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-17965, "Generic Safety Evaluation of the Single- Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System."	C-1-a	E1
MODSLUIC-C-014	18BX	HEPA filter loading and tank headspace aerosols	Release of radioactive other hazardous materials from SST to atmosphere through failed filters due to condensation of vapor in head space	Condensation of vapor in head space of SST resulting from the breaking off sluicer head causes large pressure drop in the dome space (sluicer failure, water hammer, thermal shock, corrosion or fatigue) causing reverse airflow	Waste release to atmosphere	BEU	L	IV	L	IV	L	IV	L	IV	N	Basis for NC frequency: Condensation of water vapor from sluicing operations in the headspace cannot cause pressure drops large enough to cause sufficient reverse airflow to fail a 1000 CFM HEPA filter. Therefore the frequency assigned was "beyond extremely unlikely."	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-17965, "Generic Safety Evaluation of the Single- Shell Tank (SST) Modified Sluicing Waste Retrieval System."	C-1-a	E1

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
				and HEPA failure													Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System."		
MODSLUIC-C-015	18BX	Tank headspace aerosols	Release of radioactive other hazardous materials from SST to the atmosphere from unfiltered release paths due to a tank pressurization	Sluice water evaporates in relatively dry headspace causing a momentary positive spike in headspace pressure releasing headspace contaminates through unfiltered leak paths	Headspace aerosol release through unfiltered paths	A	L	III	L	III	L	III	L	III	N	Basis for NC frequency: Heated sluice water will have a higher partial pressure than waste in the SST. Slight pressure spikes will occur when sluicing is begun. Therefore the frequency was assumed to be "anticipated."	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-17965, "Generic Safety Evaluation of the Single- Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System."	C-1-a	E1
MODSLUIC-C-029	18BX	SST headspace aerosols	Release of radioactive and other hazardous materials from SST to atmosphere due to HEPA filter plugging from water vapor (passive ventilation system)	Dissolution water heating system temperature control fails and water temperature reaches point where high temperature dissolution water flashes to steam at sprinkler nozzle causing additional moisture and plugging of the HEPA filter	Release of radioactive or hazardous material to atmosphere	U	L	III	L	III	L	III	L	III	N	Basis for NC frequency: Dissolution water heating system is not expected to supply water at temperatures exceeding the boiling point. The event frequency is therefore assumed to be "unlikely."	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on RPP-13470, "Offsite Radiological Consequences for the Bounding Flammable Gas Accident" (i.e., the bounding unmitigated offsite radiological consequences for the flammable gas accident are "low" and bound the consequences for release from contaminated facility). The "low" offsite toxicological consequences are based on calculations documented in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Onsite consequence: The "low" onsite radiological and toxicological consequences are based calculations and engineering judgments documented in RPP-17965, "Generic Safety Evaluation of the Single- Shell Tank (SST) Modified Sluicing Waste Retrieval System." Basis for NC Facility Worker consequence: The "No" for potential significant facility worker consequences is estimated based on the consequences calculated in RPP-17965, "Generic Safety Evaluation of the Single-Shell Tank (SST) Modified Sluicing Waste Retrieval System."	C-1-a	E1
MODSLUIC-D-005	33AX	SST waste	Release of radioactive other hazardous materials from SST pump pit	Electrical connector seal fault or improper	Release of tank waste to atmosphere	A	L	III	L	III	L	III	L	III	N	Basis for NC frequency: The "anticipated" frequency is based on operating experience	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on calculations presented in RPP-14499, "Offsite Radiological Consequence Analysis for the Waste TransferLeak." The "low"	C-1-a	E1

Hazardous Conditions Associated With Modified Sluicing Waste Retrieval From 100-Series SSTs That Require Further Safety Evaluation

ID	Candidate Accident	Material at Risk	Hazardous Condition	Cause	Consequence	NC Freq	NC Offsite Rad	NC Offsite Risk Bin Rad	NC Offsite Tox	NC Offsite Risk Bin Tox	NC Onsite Rad	NC Onsite Risk Bin Rad	NC Onsite Tox	NC Onsite Risk Bin Tox	NC FW Cons	Basis for NC Frequency	Basis for NC Consequence	BIN	NC Env Category
			to atmosphere due to waste leak through the electrical connections into an electrical junction box	assembly causes a flow of waste through the electrical cable up to the nearest junction box												(i.e., small leaks in transfer lines that result in a small amount of waste leakage are expected to occur).	offsite toxicological consequences are based on calculations presented in RPP-13750, "Waste Transfer Leaks Technical Basis Document." Basis for NC Onsite Worker consequence: The onsite worker radiological and toxicological consequences are qualitatively assessed to be "low" based on the low pressure and limited volume of the leaking waste. Basis for NC Facility Worker consequence: No significant facility worker consequences are expected based on qualitative assessment of the expected radiological and toxicological exposure from the material released by the event.		
MODSLUIC-E-005	33CX	SST Waste	Release of radioactive other hazardous materials from hose-in-hose transfer line or recirculation line to the atmosphere due to progressive cavity transfer pump high pressure/slug flow	Hose-in-hose transfer line ruptures due to progressive cavity pump high pressure/flow	Release of radioactive material from hose-in-hose transfer line	EU	L	IV	L	IV	H	II	H	II	Y	Basis for NC frequency: The "extremely unlikely" frequency is based on the combined frequency of no flow path or very high flow rate resulting in hose failure with large leak. The nature of a positive displacement pump is that the flow rate is based on the drive speed, not the amount of flow restriction so that a sudden rupture does not cause a flow increase.	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on calculations presented in RPP-14499, "Offsite Radiological Consequence Analysis for the Waste TransferLeak." The "low" offsite toxicological consequences are based on calculations presented in RPP-13750, "Waste Transfer Leaks Technical Basis Document." Basis for NC Onsite Worker consequence: The "high" onsite worker radiological consequence and the "high" onsite worker toxicological consequence are based on calculations for the large pipe break into a pit scenario documented in RPP-13570, "Waste Transfer Leaks Technical Basis Document." Basis for NC Facility Worker consequence: Significant facility worker consequences are expected based on qualitative assessment of the expected radiological and toxicological exposure from the material released by the event.	B-1-a	E2
MODSLUIC-C-033	33EX	SST headspace aerosols and HEPA filter loading.	Release of radioactive and other hazardous materials from SST to the atmosphere due to waste leak in headspace generating aerosols that plug HEPA filter and lead to failure (active ventilation)	A leak in the transfer pump caused by a failed component or miss-assembly causes excessive aerosols which plug the HEPA causing failure by high differential pressure	Release of radioactive and other hazardous materials to the atmosphere	A	L	III	L	III	L	III	L	III	N	Basis for NC frequency: The "anticipated" frequency is based on conservative qualitative estimation. Leaks and HEPA filter failures have occurred in the past. Even though no spray leak caused HEPA failures have occurred in tank farms, the assigned frequency is conservative and bounding.	Basis for NC Offsite consequence: The "low" offsite radiological consequences are based on calculations presented in RPP-14499, "Offsite Radiological Consequence Analysis for the Waste TransferLeak." The "low" offsite toxicological consequences are based on calculations presented in RPP-13750, "Waste Transfer Leaks Technical Basis Document." Basis for NC Onsite Worker consequence: The onsite worker radiological consequence is "low" and the onsite toxicological consequence is "low" based on qualitative assessment that only high-pressure fine spray leaks will produce consequences above guidelines for the onsite worker. Basis for NC Facility Worker consequence: No significant facility worker consequences are expected based on a qualitative assessment of the volume and form of the leaking material.	C-1-a	E2

APPENDIX D

PEER REVIEW CHECKLISTS

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CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-17965, *Safety Evaluation of the Single-Shell Tanks Modified Sluicing Waste Retrieval System*, Rev. 0

Scope of Review (e.g., document section or portion of calculation) Section 4.2.1 only

Yes	No	NA*	
[X]	[ ]	[ ]	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
[X]	[ ]	[ ]	2. Problem is completely defined.
[X]	[ ]	[ ]	3. Accident scenarios are developed in a clear and logical manner.
[X]	[ ]	[ ]	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)*
[X]	[ ]	[ ]	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)*
[ ]	[ ]	[X]	6. Computer codes and data files are documented.
[X]	[ ]	[ ]	7. Data used in calculations are explicitly stated.
[X]	[ ]	[ ]	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Documented Safety Analysis).
[X]	[ ]	[ ]	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)*
[X]	[ ]	[ ]	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)*
[X]	[ ]	[ ]	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
[X]	[ ]	[ ]	13. Spreadsheet results and all hand calculations were verified.
[X]	[ ]	[ ]	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)*
[ ]	[ ]	[X]	15. Software input is correct and consistent with the document reviewed.
[ ]	[ ]	[X]	16. Software output is consistent with the input and with the results reported in the document reviewed.
[ ]	[ ]	[X]	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)*
[X]	[ ]	[ ]	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	19. Safety margins are consistent with good engineering practices.
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[X]	[ ]	[ ]	21. Results and conclusions address all points in the purpose. *(ORP QAPP criterion 2.3)*
[X]	[ ]	[ ]	22. All references cited in the text, figures, and tables are contained in the reference list.

[illegible] 9/15/03

[X] [ ] [ ] 23. Reference citations (e.g., title and number) are consistent between the text callout and the reference list.
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[ ] [ ] [X] 30. The Table of Contents is correct.
[X] [ ] [ ] 31. All figure, table, and section callouts are correct. *Only callouts in the section being reviewed.*
[X] [ ] [ ] 32. Unit conversions are correct and consistent.
[X] [ ] [ ] 33. The number of significant digits is appropriate and consistent.
[X] [ ] [ ] 34. Chemical reactions are correct and balanced.
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[X] [ ] [ ] 36. The document is complete (pages, attachments, and appendices) and in the proper order.
[X] [ ] [ ] 37. The document is free of typographical errors. *Only the section being reviewed was checked for typographical errors.*
[X] [ ] [ ] 38. The tables are internally consistent.
[X] [ ] [ ] 39. The document was prepared in accordance with HNF-2353, Section 4.3, Attachment B, "Calculation Note Format and Preparation Instructions".
[X] [ ] [ ] **Concurrence**

Milton V Shultz *Milton V. Shultz* *9/15/03*
Reviewer (Printed Name and Signature) Date

* If No or NA is chosen, an explanation must be provided on this form.

- No computer codes were used for the calculations included in the report. All calculations were verified through hand calculations.

CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-17965, *Safety Evaluation of the Single-Shell Tanks Modified Sluicing Waste Retrieval System*, Rev. 0

Scope of Review (e.g., document section or portion of calculation): Entire document except Section 4.2.1

Yes	No	NA*	
[X]	[ ]	[ ]	1. Previous reviews are complete and cover the analysis, up to the scope of this review, with no gaps.
[X]	[ ]	[ ]	2. Problem is completely defined.
[X]	[ ]	[ ]	3. Accident scenarios are developed in a clear and logical manner.
[X]	[ ]	[ ]	4. Analytical and technical approaches and results are reasonable and appropriate. *(ORP QAPP criterion 2.8)*
[X]	[ ]	[ ]	5. Necessary assumptions are reasonable, explicitly stated, and supported. *(ORP QAPP criterion 2.2)*
[ ]	[ ]	[X]	6. Computer codes and data files are documented.
[X]	[ ]	[ ]	7. Data used in calculations are explicitly stated.
[X]	[ ]	[ ]	8. Bases for calculations, including assumptions and data, are consistent with the supported safety basis document (e.g., the Tank Farms Documented Safety Analysis).
[X]	[ ]	[ ]	9. Data were checked for consistency with original source information as applicable. *(ORP QAPP criterion 2.9)*
[X]	[ ]	[ ]	10. For both qualitative and quantitative data, uncertainties are recognized and discussed, as appropriate. *(ORP QAPP criterion 2.17)*
[X]	[ ]	[ ]	11. Mathematical derivations were checked including dimensional consistency of results. *(ORP QAPP criterion 2.16)*
[X]	[ ]	[ ]	12. Models are appropriate and were used within their established range of validity or adequate justification was provided for use outside their established range of validity.
[X]	[ ]	[ ]	13. Spreadsheet results and all hand calculations were verified.
[X]	[ ]	[ ]	14. Calculations are sufficiently detailed such that a technically qualified person can understand the analysis without requiring outside information. *(ORP QAPP criterion 2.5)*
[ ]	[ ]	[X]	15. Software input is correct and consistent with the document reviewed.
[ ]	[ ]	[X]	16. Software output is consistent with the input and with the results reported in the document reviewed.
[ ]	[ ]	[X]	17. Software verification and validation are addressed adequately. *(ORP QAPP criterion 2.6)*
[X]	[ ]	[ ]	18. Limits/criteria/guidelines applied to the analysis results are appropriate and referenced. Limits/criteria/guidelines were checked against references. *(ORP QAPP criterion 2.9)*
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[X] [ ] [ ] **Concurrence**

K. Ford (signature) 9/15/03
Reviewer (Printed Name and Signature) Date

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CHECKLIST FOR TECHNICAL PEER REVIEW

Document Reviewed: RPP-17965, Rev. 0

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Comments: RPP- 17965, Rev. 0

Tech Edit: CAROL LYNCH C. Lynch 9-15-03
Reviewer (Printed Name and Signature) Date

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